With the compliments of the Society

Proceedings

OF

The Canadian Phytopathological Society

Inaugural Session

DECEMBER 19 AND 20, 1929

EDITORIAL COMMITTEE

H. T. GÜSSOW

J. G. COULSON J. H. CRAIGIE

OTTAWA

Printed for The Canadian Phytopathological Society by the authority and courtesy of the Hon. Robert Weir, Minister of Agriculture, Dominion of Canada

1930

June 1930—*Price, $3.50*

THE CANADIAN PHYTOPATHOLOGICAL SOCIETY

LIST OF OFFICERS AND COUNCIL 1929-1930

President

H. T. Güssow, Central Experimental Farm, Ottawa, Ont.

Vice-President

W. P. Fraser, The University of Saskatchewan, Saskatoon, Sask.

Secretary-Treasurer

T. G. Major, Central Experimental Farm, Ottawa, Ont.

Councillors

D. L. Bailey, The University of Toronto, Toronto, Ont.

J. G. Coulson, McGill University, Macdonald College P.O., Que.

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THE CANADIAN PHYTOPATHOLOGICAL SOCIETY

INTRODUCTION

A new national organization to which the name Canadian Phytopathological Society has been given was founded on December 19, 1929, at a meeting of the Canadian Division of the American Phytopathological Society, held in the headquarters of the Canadian Society of Technical Agriculturists, at Ottawa, Ont.

This independent organization replaces the Canadian Division of the American Phytopathological Society founded at Guelph, Ont., in the year 1919. For several years there has been a feeling that a more distinctly Canadian organization of plant pathologists was desirable. A definite move in this direction was made at the Tenth Annual Meeting of the Canadian Division at Guelph in 1928. At that meeting a resolution was adopted authorizing the council of this division to proceed with a mail referendum on the question as to whether the members of the Canadian Division were in favour of separating from the American Phytopathological Society with the view of forming a more national and independent organization. The referendum was held early in 1929 and revealed an almost unanimous desire on the part of Canadian phytopathologists to organize a scientific society of their own.

The Dominion Department of Agriculture generously offered to assist such a new society in the publication of its proceedings. The present issue is the first to appear. The president, council and charter members of the new society, desire here to express their cordial appreciation of the support which the society has received from the Dominion Department of Agriculture, especially its distinguished minister, the Hon. Dr. W. R. Motherwell and his deputy, Dr. J. H. Grisdale, without whose generous response it would have been difficult to produce the Proceedings of the Canadian Phytopathological Society in its present form. The proceedings are to appear once a year as soon as possible after each annual session of the society, and will include the technical papers presented at any such session.

The society is further indebted to the Canadian Society of Technical Agriculturists for their good will and support, especially in placing their commodious headquarters at Ottawa at the disposal of the society, and in offering very favourable terms of affiliation, including facilities for the more immediate publication of Canadian contributions to the science of plant pathology in the official organ of the C.S.T.A. viz.: "Scientific Agriculture," and in a manner that their identity as contributions from The Canadian Phytopathological Society will be preserved.

INAUGURAL MEETING

December 19, 1929

(G. H. Berkeley, St. Catharines, in the chair)

The proceedings and minutes of the previous meeting under the auspices of the Canadian Division of the American Phytopathological Society held at Guelph in December, 1928, were read and approved.

The chairman then addressed the meeting relative to the program of the session and proceeded with the appointment of committees. The report of the Organization Committee was duly submitted and approved by the members present.

The meeting next considered and discussed fully a draft of the constitution of the proposed Canadian Phytopathological Society finally submitted as follows:—

THE CANADIAN PHYTOPATHOLOGICAL SOCIETY

CONSTITUTION

Article I

This society shall be known as The Canadian Phytopathological Society.

Article II

Membership

Section 1.—All persons interested in the science or practice of plant pathology shall be eligible for membership.

Section 2.—There shall be four kinds of members:—

(a) Regular members.

(b) Life members: any member who may desire to compound for his annual subscriptions by the payment of the life members' fee.

(c) Student members: any junior, senior or postgraduate student at a university or agricultural college of recognized standing.

(d) Honorary members: any person, not a member of the society, who has rendered eminent service, or has done honour in any way to the society or to the profession, shall be eligible for election as an honorary member.

(e) Charter members: all members joining the Society prior to March 1, 1930, shall be duly enrolled as charter members.

Article III

Membership Fees

Each member shall pay such fees as the society shall determine.

Article IV

Election of Members

Section 1.—Regular and student members may be elected only at any regular meeting of the society. Applications for membership on the forms provided for this purpose must be endorsed by at least two members of the society, and must be approved by the council.

Section 2.—Honorary members shall be recommended by the council, and be elected by unanimous consent of the members present at any regular meeting of the society.

Article V

Officers

The officers of the society shall consist of one president, one vice-president, one secretary-treasurer, and two councillors (one of whom shall be the retiring president). The president, vice-president and councillors shall serve for one year, and the secretary-treasurer for two years. The council shall have power to fill any vacancies occurring in the interim between elections. The council shall consist of the president, vice-president, secretary-treasurer, the retiring president, and one additional councillor to be elected by the society.

Article VI

Election of Officers

(a) The nomination of officers shall be by ballot.

(b) Nomination blanks shall be sent to each member in good standing *(e)*, and must be returned to the Secretary on or before the date specified thereon.

(c) The ballot shall be prepared by the secretary and, for each office, shall contain the names of the three members receiving the greatest number of nomination votes for that office. In the event of there being less than three nominees for any office, additional nominations shall be made by the council. Not more than three names shall appear on the ballot for any one office. The chairman is empowered to withhold his vote until the nominations have been counted and to cast the deciding vote in case of a tie.

(d) One ballot shall be mailed to each member. Each member in good standing *(e)* shall be entitled to cast one vote for each office. The ballots shall be counted by a committee appointed by the council. The secretary shall be an *ex officio* member of this committee. The candidates for each office receiving the greatest number of votes shall be declared elected.

(e) A member in good standing is one with fees fully paid.

Article VII

Meetings

An annual meeting shall be held at such time and place as the council may select, and additional meetings may be arranged by the council at its discretion.

Article VIII

Quorum of Council

Three shall constitute a quorum of the council for the transaction of business.

Article IX

Committees

Committees, whether special or standing, may be appointed by the council at any time between annual meetings, or at an annual meeting.

Article X

Council Meetings

The council shall meet at least once each year, but may, however, be called together by the president if he deems it necessary.

Article XI

The society may become affiliated with any other society providing such affiliation is authorized by majority vote of all members in good standing.

Article XII

Publication of Proceedings

There shall be published each year the proceedings of The Canadian Phytopathological Society.

Article XIII

This constitution may be amended only by approval of 75 per cent of the membership of the society. Such vote shall be taken by mail ballot, following a notice of motion and discussion at an annual meeting. Copies of such notices of motion must be mailed by the secretary to each member at least two weeks previous to the date of the annual meeting.

All amendments to this constitution shall be published in the proceedings of the society.

Approval of Constitution

Extract from the minutes of the first annual meeting of The Canadian Phytopathological Society held at Ottawa on December 19 and 20, 1929.

"Moved by D. L. Bailey and seconded by H. T. Güssow, that this constitution be adopted with the provision that for the first year Article VI shall be suspended and election of officers take place by vote of the members present at this meeting.—Carried unanimously.

"Moved by H. T. Güssow and seconded by A. W. Henry, that a committee be appointed to edit the constitution.—Carried.

"The chairman announced that the editing of the constitution should be carried out by the already appointed Editorial Committee."

SPECIAL COMMITTEES

The following special committees were appointed, the name of the chairman appearing first in each case:—

Resolutions—A. W. Henry, A. R. Walker, D. J. MacLeod.
Editorial—H. T. Güssow, J. H. Craigie, J. G. Coulson.
Affiliations—G. H. Berkeley, P. M. Simmonds, H. S. Jackson.
Publicity—D. L. Bailey, Irene Mounce, T. G. Major.
Nominations—J. G. Coulson, J. H. Craigie, H. S. Jackson, A. R. Walker, T. G. Major.

REPORT OF NOMINATIONS COMMITTEE

The report of the Nominations Committee was received and adopted, the following nominations being made:—

For President—H. T. Güssow and J. E. Howitt.
For Vice-President—W. P. Fraser and W. T. MacClement.
For Secretary-Treasurer—I. L. Conners and T. G. Major.
For Councillors—D. L. Bailey, G. H. Berkeley, and J. G. Coulson.

Successive ballots were then held for each office, as a result of which the following officers were elected:—

President—H. T. Güssow.
Vice-President—W. P. Fraser.
Secretary-Treasurer—T. G. Major.
Councillors—D. L. Bailey and J. G. Coulson.

INAUGURAL BANQUET

On the evening of December 19 at 7.30 p.m. a most enjoyable banquet was held in the Chateau Laurier. In addition to the phytopathologists attending the inaugural sessions many representatives of other branches of agricultural science were present. The newly elected president acted as toastmaster. The program was as follows:—

TOASTS

H. M. The King

Proposed by the Chairman

ADDRESS OF WELCOME

Mayor-Elect of Ottawa, Frank Plant, Esq.

"THE NEW SOCIETY"

The Hon. Dr. W. R. Motherwell,* Minister of Agriculture

Dominion Department of Agriculture—J. H. Grisdale

Dominion Experimental Farms—E. S. Archibald

Provincial Department of Agriculture—D. L. Bailey

Canadian Universities—J. E. Howitt

Canadian Society of Technical Agriculturists—W. T. Macoun

National Council for Industrial and Scientific Research—H. M. Tory

The Entomological Branch—Arthur Gibson

ADDRESS

"Twenty Years of Plant Pathology in Canada"—H. T. Güssow

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* Dr. Motherwell unfortunately was unable to attend this function, being still convalescent after a serious illness.

BUSINESS SESSION

December 20, 1929

The meeting was called to order by the president at 10 a.m. The president, on behalf of the council, thanked the members for the honour done in electing them to office and bespoke their co-operation in making the new society a success.

An invitation from the President of the University of Western Ontario was read, in which the society was invited to hold its next meeting at that institution. Professor Walker was delegated to convey the thanks of the society to the president of the university. It was decided, however, after some discussion, to hold the next annual meeting in June, 1931, in conjunction with the annual convention of the Canadian Society of Technical Agriculturists.

In presenting the report of the Affiliations Committee it was recommended that steps be taken to affiliate with the Canadian Society of Technical Agriculturists.

The following resolutions were adopted unanimously:—
Resolved that—

(1) Whereas our meetings at Ottawa on December 19 and 20, 1929, have been greatly facilitated by privileges afforded to us by the C.S.T.A. in providing office space and assembly rooms for the said meetings, we take this opportunity of expressing our sincere thanks to the executive of that society for their many kindnesses. Be it also resolved that we express our deep regret to the president and secretary of the C.S.T.A. in their serious illnesses at the time of our meetings and our hope for their early and complete recovery.

(2) Whereas illness has also fallen upon the Hon. Dr. Motherwell and prevented him from being with us at our inaugural meetings and from being present to address us at our banquet, we express to him our unanimous feelings of regret and hope for a quick recovery.

(3) Whereas the officers of the Dominion Department of Agriculture have contributed so liberally to the support and encouragement of our new organization and have extended us so many courtesies both in the past and at our present meetings, we express our sincere appreciation for these evidences of their interest in our organization.

(4) Whereas the committee under the chairmanship of Dr. G. H. Berkeley, gave so freely of their time and energy in drafting a tentative constitution of our society and in making the necessary arrangements for the organization meeting the society takes this opportunity of expressing its thanks for these much appreciated services.

(5) Whereas The Canadian Phytopathological Society has been the recipient on the occasion of its inaugural meetings of several gifts from individuals which have contributed materially to the pleasure of its members, we ask our secretary to communicate our thanks and appreciation to the donors.

(6) Whereas we as a branch of The American Phytopathological Society have benefitted greatly by the privilege of membership in that society and by our long and intimate association with our American colleagues, we desire to express our deepest appreciation for the fine spirit of fellowship always accorded us, and on the occasion of the formation of our new Canadian Phytopathological Society to assure them of our continued and whole-hearted support and co-operation.

(7) Whereas the National Research Council of Canada has contributed so generously to the development of plant pathology in Canada in the past and now assures the new society of its continued interest and willingness to assist the work of the society in every way possible, we desire at this time to acknowledge our indebtedness to the council and extend our sincere thanks for the splendid co-operation given us.

A motion was adopted setting the following scale of membership fees:—

Regular membership—$3 per annum.
Life membership—$60.
Student membership—$1 per annum.

After some discussion it was decided that members expecting to attend the International Botanical Congress at Cambridge, England, should notify the secretary-treasurer in order that official representatives may be appointed.

The appointment of a special membership committee was authorized.

A motion to the effect that student members should be enrolled as charter members was carried.

The following committee was appointed to conduct an inquiry into the question of the common names of plant diseases in Canada:—

I. L. Conners (Chairman), Clara Fritz, R. E. Stone, A. W. Henry, H. N. Racicot, F. L. Godbout.

The following signed the register at the inaugural meetings: E. S. Archibald, E. A. Atwell, D. L. Bailey, G. H. Berkeley, R. Boothroyd, I. L. Conners, J. G. Coulson, J. H. Craigie, N. Criddle, E. A. Eardley, W. Ferguson, Clara W. Fritz, Arthur Gibson, F. L. Godbout, F. J. Greaney, H. T. Güssow, A. W. Henry, A. J. Hicks, J. L. Howatt, J. E. Howitt, R. R. Hurst, H. S. Jackson, Edward Lavallie, G. A. Ledingham, J. E. Machacek, L. S. McLaine, D. J. MacLeod, N. A. MacRae, T. G. Major, Irene Mounce, William Newton, R. Painter, H. N. Racicot, G. B. Sanford, P. M. Simmonds, A. R. Walker.

TECHNICAL SESSION

PROGRAM

Friday December 20, 1929

"The efficiency of various sulphur dusts in controlling stem rust and the effectiveness of different methods of application."—F. J. Greaney.

"The relation of wheat varieties at two stages of maturity to sixteen physiologic forms of *Puccinia graminis Tritici*."—C. H. Goulden, Margaret Newton, A. M. Brown.

"A New Fungus associated with Root Rot of Wheat in Saskatchewan" (twenty minutes Lantern).—T. C. Vanterpool, G. A. Ledingham.

"Common Names of Plant Diseases occurring in Canada"—I. L. Conners.

"Strawberry Root Rot" (fifteen minutes).—A. R. Walker.

"Increased Yields from Spraying and Dusting Late Potatoes."—J. E. Howitt.

"Factors Influencing the Character of Bordeaux Mixture."—W. Newton, F. B. Johnson, C. Yarwood.

"A Root Rot of Sweet Clover and Related Crops, caused by *Plenodomus Meliloti* Dearness and Sanford, new species" (20 minutes Lantern).—G. B. Sanford.

"Further Notes on Heterothallism in Some Species of Wood-destroying Fungi" (fifteen minutes).—Irene Mounce.

"Preliminary Studies on the Hybridization of Physiologic Forms of *Puccinia graminis Tritici*."—Margaret Newton, T. Johnson, A. M. Brown.

"A Fusarium Disease of the Cucumber Fruit" (fifteen minutes).—B. G. Montserin.

"The Influence on Yield and Grade of Harvesting Rusted Wheat at Different Stages of maturity."—F. J. Greaney.

"The Relation Between Stem Rust Infection and the Yield of Wheat."—C. H. Goulden, F. J. Greaney.

"Amputation Experiments upon Wheat Roots in Relation to the Diagnosis of Root Rot Diseases." (fifteen minutes).—P. M. Simmonds, B. J. Sallans.

"A Progress Report on the Study of the Biology of *Ustilago nuda* (Jens.) K. and S."—N. A. MacRae.

"Some Studies on Seed Treatments."—F. T. Godbout.

"Some Observations on the Effect of Gypsum Upon Common Scab of the Potato, *Actinomyces scabies* (Thax.) Güssow."—J. G. Coulson.

THE EFFICIENCY OF VARIOUS SULPHUR DUSTS IN CONTROLLING STEM RUST AND THE EFFECTIVENESS OF DIFFERENT METHODS OF APPLICATION

(Abstract)

In 1929 under an artificially induced epidemic of stem rust of wheat (*Puccinia graminis* Pers. var. *Tritici*), Erikss. and Henn., dusting experiments were carried out to determine the efficiency of various sulphur dusts and the effectiveness of different methods of application. In each experiment late sown Marquis wheat plots were arranged in the form of a Latin Square and the yield data were studied statistically.

In comparing the fungicidal efficiency of six kinds of sulphur dusts, it was found that five 30-pound weekly applications of such dusts as Kolodust, Koppers Lime Dust, Electric Sulphur, Koppers Dust, and Sulfodust, gave extremely effective rust control. Plots dusted with Kolodust showed 39 per cent stem rust infection and yielded $34 \cdot 4 \pm 1 \cdot 06$ bushels per acre, as compared with 71 per cent rust and $24 \cdot 7 \pm 0 \cdot 72$ bushels per acre in the checks. Gas dust, a recovered sulphur dust, did not give satisfactory rust control in the field. Three oxidized sulphur dusts, although giving good rust control and significantly increasing the yield, were less effective fungicides than ordinary Kolodust.

The best rust control was achieved when dusting was begun on July 17. Weekly applications, at 30 pounds per acre, begun July 24, gave fairly satisfactory control but when applications were delayed until July 31, two subsequent weekly dustings were ineffective in controlling rust. To insure the most effective control, dusting should be commenced when rust is first found in the field, and the treatments should be continued until the crop matures.

In another experiment the standard treatment (six 30-pound per acre dustings) gave unusually satisfactory results. The average amount of rust in the plots so treated was 41 per cent as compared with 72 per cent in the checks. Yield was increased 16·7 bushels per acre and the grade improved from No. 4 to No. 2 Northern. Equally favourable results were obtained however, by another treatment in which three dustings were made in relation to weather conditions. In 1929, three 30-pound applications made immediately after rain, gave as effective rust control as six applications which bore no relation to the weather. The amount of rust in the plots dusted three times just before rain indicated that the efficiency of the fungicide was considerably reduced when dusted plants were exposed to light rain. (F. J. Greaney, *Dominion Rust Research Laboratory, Winnipeg, Man.*)

THE REACTIONS OF WHEAT VARIETIES IN TWO STAGES OF MATURITY TO SIXTEEN PHYSIOLOGIC FORMS OF *Puccinia Graminis* Pers. var. *Tritici* ERIKSS. and HENN.

(ABSTRACT)

The literature is reviewed leading up to the acceptance of the theory that some varieties of wheat possess a type of resistance to stem rust which is not exhibited in the seedling stage. This is referred to as mature plant resistance and in previous studies in two crosses has been shown to be independent in inheritance of seedling resistance.

Fourteen varieties of wheat were tested in the seedling stage and in the mature plant stage in the greenhouse to sixteen physiologic forms of stem rust. It was possible to divide the varieties into three groups on the basis of these tests. (1) Varieties showing no evidence of mature plant resistance: Garnet, Marquis, Quality, and Khapli. (2) Varieties showing varying degrees from an indication to very distinct evidence of the presence of mature plant resistance: Reward, Kota, Marquillo, Black Persian, Hope, H-44-24, Pentad and Acme. (3) Varieties showing no appreciable difference between the seedling and mature plant reactions, but suspected of possessing the mature type of resistance in a fairly high degree: Vernal emmer, and Iumillo. These varieties are highly resistant in the seedling stage to most physiologic forms and differentiation of the reactions in the two stages is consequently very difficult or impossible. The indication of mature plant resistance is the low percentage of infection obtained in the mature plant stage as compared with other varieties, such as Khapli, possessing a similar degree of seedling resistance.

It is shown that the reactions obtained in the mature plant stage with respect to size of pustules and percentage of infection agree with any theory accounting for mature plant resistance on the basis of a mechanism preventing the entrance of the parasite. (C. H. GOULDEN, MARG. NEWTON, and A. M. BROWN, *Dominion Rust Research Laboratory, Winnipeg, Man.*)

THE "BROWNING" ROOT-ROT OF CEREALS

(ABSTRACT)

A specific root-rot of wheat and other cereals is widespread over Saskatchewan and occasions severe losses in some seasons. In early June the outer leaves of the young plants become discoloured; the number of tillers is reduced, growth is delayed and yield considerably lessened. One of the chief diagnostic features is the presence of necrotic root tips containing Pythium-like oospores. Accumulated observations indicate that the disease is most severe in a cool, wet spring, followed by warm, dry weather. But, when the remainder of the growing season is favourable the plants recover markedly. This disease has been designated as browning root-rot.

Several different types of Pythiaceous fungi have been isolated from infected roots of wheat seedlings grown in soil collected from fields where the disease was present. A few of these have been shown to be definitely parasitic on the roots of wheat plants in pot experiments in the greenhouse.

A hitherto undescribed fungus belonging to the lower PHYCOMYCETES was found associated with root injury of wheat, barley, and rye seedlings grown in Regina Clay soil from infested fields of southern Saskatchewan. Morphological studies of the parasite show that it is apparently most closely related to members of the ANCYLISTALES. The fungus is described as *Lagena radicicola* n.g., n. sp. While under certain favourable conditions this parasite is capable of causing definite injury to wheat, it appears that certain *Pythium spp.* are the chief factors in the production of this particular root-rot problem in Saskatchewan. (T.C. VANTERPOOL and G. A. LEDINGHAM, *University of Saskatchewan, Saskatoon, Sask.*)

COMMON NAMES OF PLANT DISEASES OCCURRING IN CANADA

I. L. CONNERS

Central Experimental Farm, Ottawa, Ont.

Ten years ago at the annual meeting of the newly organized Canadian Division of The American Phytopathological Society the plant pathologists of Canada decided to organize a plant disease survey for this country. The members of the society agreed to supply what information they might collect in their district to a committee, who undertook to summarize the data. Almost immediately the Division of Botany, Dominion Department of Agriculture, agreed to publish the reports. Dr. W. H. Rankin, and Prof. W. P. Fraser, were appointed a committee to undertake the work and under their names the first and second annual reports of the Plant Disease Survey for the years 1920 and 1921 were published in mimeograph form. Upon Dr. Rankin leaving the Division of Botany, Mr. F. L. Drayton was placed in charge of the work and the Plant Disease Survey became one of the authorized projects of the division. The third and fourth annual reports for the years 1922 and 1923 were compiled and published. No annual report was brought out for 1924, but in its stead there appeared in print in 1926 "A Summary of the Prevalence of Plant Diseases in the Dominion of Canada, 1920-1924." Under the pressure of other duties no further reports have appeared until recently when Messrs. J. B. McCurry and A. J. Hicks published the fifth annual report covering the year 1925. Separate reports covering the intervening years are in the course of preparation and will be published.

Besides supplying much useful information on the occurrence and prevalence of plant diseases, plant disease survey reports tend to standardize the common names in use for our plant diseases. However, this is only incidental to their main function and a brief examination of the current literature shows that one disease may pass under several names and the same name may be used for several distinct diseases. In addition, in diseases caused by pathogenic organisms the same pathogen may be masquerading under more than one name on account of the unstable condition of Botanical Nomenclature.

The first attempt to remedy the present instability and the resulting confusion in the names applied to plant diseases was made recently by the Plant Pathology Sub-committee of the British Mycological Society when it compiled the "List of Common Names of British Plant Diseases" and published it in the Transactions of the Society, Vol. 14, pp. 140-170, March, 1929. The object of the committee was to "select for each disease a *single* common name wherever possible, the use of which it is desired to encourage throughout the British Isles and the Empire." In the case of parasitic diseases "the scientific names of the causative parasites have been included" and "the list is therefore arranged in two parallel columns; on the left, under the name of the host plant, w.ll be found the common name recommended for the disease; on the right, the scientific name of the parasite. One important feature of this list was the care taken "to ensure that the correct scientific name and authority are given for each parasite, according to the International Rules of Botanical Nomenclature. Where investigation has shown that a scientific name hitherto in common use is incorrect, it has been amended." Nearly all the common names that were chosen were already in general use in Great Britain. For a few diseases, "where one parasite causes two or more types of disease symptoms, particularly in different parts of the host plant," a name for each was recommended.

The British list will no doubt prove useful to the plant pathologist throughout the British Empire, and the attractive format will be welcomed by everyone. It will probably be of most value as a model in the compilation of similar lists covering other parts of the Empire. As it contains only the diseases in Great Britain the list is a handy reference for diseases of wide distribution in countries

of the temperate region. In a country such as Canada, however, there are many diseases which do not occur in Great Britain and several diseases in the latter country which are unknown in the former. Besides this limitation several of the common names selected by the committee are unsuitable under Canadian conditions, the compilers naturally selecting those names that were in common use in Great Britain. For instance plant pathologists in Canada have been careful to designate the disease caused by *Puccinia graminis* Pers. as "stem rust" instead of "black rust" in order that the important red or uredinial stage would not be overlooked. Before this name was adopted the uredinial stage was known as red rust and its importance in the life-history of stem rust was not understood by the layman. In many instances where the common name proposed in the British list differs from the name now in use in Canada it is a matter of indifference which one is used and frequently the change would be welcomed. There remains, however, a small category where the names are not in the Canadian idiom. As an example may be cited the restriction in the use of the word "ear" which in Canada is applied to the female inflorescence of maize, and the word "head" has come to be used for the spikes of wheat, etc. For this reason it is more appropriate to speak of "head blight" of wheat rather than "ear blight" in this country.

In addition to the above limitations of the British list it possesses certain defects common to plant disease surveys or manuals. The names employed are usually selected from those in use among growers or plant pathologists. As many of these names have been chosen with little or no regard for other diseases on the same hosts or for similar diseases on other hosts some of the names are not particularly appropriate.

The common name should indicate some important characteristic of the disease to distinguish it from all other diseases on the same host. Naturally where one part of the host plant tends to be affected more severely than another this fact is usually indicated in the name.

On the other hand where a parasitic fungus is the cause of the disease, the generic name of the organism should not be used in the common name. The British Committee's suggestion to use "Black Scurf" and "Stem Canker" in place of "Rhizoctonia" for the names of the disease caused by *Corticium Solani* Bourd. and Galz. on the tuber and stem of the potato respectively is to be commended.

The replacement of such names as "Stewart's disease" by "bacterial wilt" of sweet corn (*Aplanobacter Stewarti* (E. F. Smith) McCulloch) and "Grand Rapids disease" by "bacterial canker" of tomato (*Aplanobacter michiganense* E. F. Smith) as done in the United States Department of Agriculture Plant Disease Reporter is also thoroughly sound.

The common name should not allude to microscopic characters of the parasite. For this reason, "crown rust" of oats, a name suggested by the finger-like processes at the apex of the teliospores is not as good a name as "leaf rust."

The designation of diseases caused by parasites belonging to the same genus or closely related genera, by a common name, wherever such a name is applicable seems to be a first-rate practice.

Keeping the above considerations in mind it is the speaker's belief that the compilation of a "List of Common Names of Plant Diseases Occurring in Canada" would be welcomed in this country. As the plant pathologists as an organized group were responsible for the initiation of the Plant Disease Survey and as individuals are supplying the material for the published reports it would seem appropriate that they should again take the initiative in the preparation of a list of common names of plant diseases that would be suitable for use in Canada. I would therefore suggest that a Committee be appointed* with power to prepare such a list, to be submitted to the society for their approval.

* The Committee suggested has been duly appointed. [Ed.]

STRAWBERRY ROOT-ROT

A. R. WALKER

The University of Western Ontario, London, Ont.

During recent years growers have frequently complained of a blackening and dying of the roots of strawberry plants. This trouble was at first merely considered to be the result of winter killing but is now recognized as a definite disease. It is commonly called root-rot or black-root.

The trouble is quite common in the strawberry section in the vicinity of the Great Lakes, both in Canada and the United States. Reports from various districts show that it is found elsewhere as well. Berkeley and Jackson (1) reported it from Ontario in 1923 as occurring rather generally in certain parts of the Niagara Peninsula. Coons (2) similarly reported root-rot from Michigan in 1924. The same year Sherbakoff (3) reported it as of wide occurrence in Alabama and Tennessee. Small (4) reported it from England where he found it on strawberry plants grown under glass at Cheshunt, Herts., in 1925. Wardlaw (5) reported a disease with somewhat similar symptoms occurring in Scotland causing considerable loss to the strawberry growers in the Clyde valley.

Coons found *Rhizoctonia* sp. constantly associated with the disease in Michigan. Small found a fungus which he believed to be a species of *Diplodina* associated with the disease in England and Wardlaw connected the trouble found in the Clyde valley with *Pythium proliferum* de Bary. To date no cause has been satisfactorily assigned to the root-rot as it occurs in the Niagara Peninsula. However, some of the data collected during the seasons 1927, 1928 and 1929, are sufficiently interesting to justify a preliminary report.

The modification in appearance of the host plant is not very striking during the early stages of this disease. It may easily happen that a plant appearing quite normal will show root-rot when dug up. In the more advanced stages, however, the symptoms on the aerial portion are quite pronounced. If a plant is attacked while small it fails to develop, so is readily distinguished by its stunted, undernourished appearance. When a plant which has almost reached normal size is attacked the stunting effect is naturally not produced. These plants soon appear as if they suffered from deficient water supply. The outer leaves wither early and die. In a severe case the entire plant withers and dies. If the attack is early and of a severe nature, the fruit fails to set or at best a very much reduced crop of inferior fruit results.

The symptoms on the under ground portion of the plant are even more striking. The infested roots soon become black and later decay. The roots of strawberry plants normally become dark in late summer. However, the root system of a diseased plant can be distinguished from this normal condition. The diseased roots are blacker and the cortex becomes quite soft and flakes off. Moreover, healthy plants are usually producing new white roots about the time the earlier formed roots commence to darken. A diseased root system seldom produces new roots.

Plants may show symptoms of the disease at any age but two periods are most susceptible. The first is shortly after young plants are set out. The second, which is much more common, occurs at fruiting time. The host often appears quite normal until fruiting time when it may fail to produce fruit and dies down very quickly. Sometimes fruit is produced but it is of small size and general undersirable appearance.

Investigations were carried out chiefly along the following lines:—

A. *Work with Organisms*—

1. Isolations from diseased plants and from soil bearing diseased plants.
2. Inoculation of healthy plants with suspected pathogens and re-isolations from those developing symptoms of disease.

B. *Cultural Studies*—

1. A survey of strawberry fields in the Niagara peninsula to ascertain if any uniformity of cultural practices could be correlated with presence of root-rot.
2. Relation of soil to spread of the disease.

Work with Organisms—

Isolations were made on a large scale from the crowns and roots of diseased plants. The method of making isolations was as follows: The crown and roots were washed well, dipped in 1/1000 mercuric chloride solution for a few seconds, rinsed in 70 per cent alcohol and then allowed to dry. Short sections of roots were cut off with a flamed scalpel or small portions of the crown were similarly removed. These pieces were incubated on potato dextrose agar slants at room temperature.

In the summer of 1927 thirty-nine different organisms were isolated from diseased roots and crowns. Many of these were typically saprophytic organisms. Some occurred rarely or only once. The most promising organisms isolated were used for inoculation of healthy plants. The inoculations were made by inserting a quantity of the inoculum into an incision made in the crown of the plant a short distance below the surface of the ground.

Similar inoculations were made in the crowns of healthy plants using a small quantity of macerated leaves from diseased plants for inoculum. In a few cases leaves were macerated, extracted for a short time in distilled water and the extract filtered through a medium Mandler diatomaceous filter. This filtrate was injected into incisions in the crowns of plants.

During the season twenty isolated groups of plants were inoculated in the field. One of these plots of eleven plants was inoculated with a *Ramularia* sp. Eight of these plants showed pronounced disease symptoms. Five of them yielded positive re-isolations. None of the plants inoculated with macerated leaves or leaf extract showed any of the typical disease symptoms. A few of the other inoculated plants sickened or even died, but none of them yielded positive re-isolations.

Isolations from diseased roots and crowns during 1928 yielded a much narrower range of organisms—perhaps due to better technique. These were mostly *Fusarium* and *Ramularia* spp. though a few other organisms including eelworms were isolated. Only the *Fusarium* and *Ramularia* were used for inoculation.

The inoculated plants were of the Glen Mary and Wm. Belt varieties which had been set out early that season. A few of these plants showed symptoms of disease late in the summer and were removed for re-isolation purposes. However, the majority of inoculated and check plants were allowed to overwinter unprotected in the field.

These plants began to show symptoms of disease the end of May, 1929, and by the third week in June a large number of the plants had contracted the malady. The following table presents the results obtained from these inoculated plants up to the end of the 1929 season.

Inoculated and check plants	Number of plants	Diseased or dead	Healthy	Unidentified	Number of plants used for re-isolations	Positive re-isolations	Per cent of casualties	Per cent of positive re-isolations
Ramularia sp......	32	24	6	2	10	10	75	100
Fusarium sp.......	20	16	2	2	4	2	66	50
Checks...........	52	34	12	6	....	....	65	....

The high percentage of casualties among check plants indicates that the method of inoculation is too severe so later in the present season plants of another series were inoculated by placing the roots in a spore suspension. Results are not yet obtainable.

The 1929 isolations from plants naturally contracting the disease were made mostly from two experimental plots of Glen Mary or Wm. Belt varieties set out during the previous season. A few isolations were made from plants obtained in grower's fields.

The results which follow are rather in accord with those obtained during the 1928 season, i.e. an excess of *Ramularia* and *Fusaria*. Isolation from forty plants yielded sixteen cultures of *Ramularia* sp., fourteen of *Fusarium* spp. and eight a sterile mycelium, i.e. 40 per cent of the infected plants yielded *Ramularia* sp. and 35 per cent gave *Fusarium* spp. The remainder of the organisms obtained were mostly Mucor, bacteria or eelworms.

Cultural Studies—

A survey of strawberry patches in the Niagara Peninsula was undertaken at the end of July, 1928. This time was chosen for two reasons: First, the heaviest casualties occur at fruiting time. Secondly, with the failure or success of the recent crop fresh in their memory it is easier to gather data from growers.

The principal practices which seemed in any way related to the prevalence of root-rot may be briefly summarized as follows:—

1. The varieties which are grown on a commercial scale in the peninsula are all susceptible, i.e., Glen Mary, Wm. Belt, Parsons Beauty, Senator Dunlap. The Glen Mary plants appeared the most susceptible.
2. Strawberry patches obtained from a weakened patch of the previous year were often heavily infested. Several bad patches were traced to a common origin. Conversely, patches of various growers obtained from a common healthy stock were healthy.
3. Many growers do not mulch regularly and these unprotected patches showed a much higher percentage of root-rot than mulched ones. A few exceptions were noted where a particularly heavy foliage the previous year may perhaps have served somewhat as a natural mulch.
4. A five or six year rotation is about the shortest compatible with freedom from root-rot.

The ability of the disease producing organism or substance to live over from year to year in the soil, as indicated under crop rotation of the survey, was checked experimentally. Soil from various infested fields was potted and similar sterilized potted soil was used as a check. These pots were placed out along strawberry rows where runners were being freely produced in 1928. Runners were trained so that sets would be made in the potted soil.

These plants were allowed to remain in the field over winter with the pots down to the rim in the soil. During 1929 a record was kept of these potted plants as shown in the following table.

RECORD OF POTTED PLANTS

—	Total number of plants used	Healthy plants on date indicated	Very weak plants on date indicated	Dead plants on date indicated	Per cent of casualties	Total number of berries picked	Number of berries per plant alive on July 15
SUSPECTED SOIL—		*	*	*			
Lot No. 1........	9	2, 1	1, 1	3, 3	33	2	0·34
Lot No. 2........	19	7, 0	5, 14	0, 2	10	55	3·2
Lot No. 3........	12	5, 1	2, 2	0, 6	50	44	7·3
Total.......	40	14, 2	8, 17	3, 11	27·5	101	3·5
STERILE SOIL...........	15	9, 12	2, 0	0, 0	0	·100	6·7

* The figures in the left hand columns in these three cases denote the results of observations made May 8th; those in the right hand columns, observations made July 15th.

A noteworthy point brought out by third and fourth columns of figures is that even if the number of dead plants is not very high in the suspected soil as in No. 2, a large number of plants still living are in a very weak, unhealthy condition.

The diseased plants which appeared in the suspected soil were removed as soon as observed and isolations were made from them. In all cases *Ramularia* sp. was isolated along with other organisms in some cases.

A biological and chemical examination of the suspected and sterile soils did not reveal anything which appeared to have any relationship to root-rot.

In conclusion a statement made at the first of the present paper might be repeated. The disease cannot as yet be assigned to any definite cause. However, as it exists in the Niagara Peninsula indications are that the *Ramularia* sp. so frequently met in the work may be a factor. It may not be wholly responsible, however, and cultural conditions of the host may introduce important predisposing factors.

The writer wishes to express his indebtedness to Dr. G. H. Berkeley, Officer in charge of the St. Catharines Laboratory, for suggesting the problem and for helpful criticisms, most of this work has been done in the fields and laboratories under his direction.

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INCREASED YIELDS FROM SPRAYING AND DUSTING LATE POTATOES

(ABSTRACT)

Will it pay us to spray or dust our potatoes with a fungicide every year? This is a question that is often asked by our Ontario potato growers. In order to secure some definite information on this point, a five-year series of experiments has been started. These experiments have been conducted at the Ridgetown Experiment Station by Mr. D. R. Sands of the Botanical Department for the past two years. The results obtained from these two years' experiments bring out some interesting points.

On June 15, 1928, three plots of Dooley potatoes were planted, and on July 19 the first spraying and dusting was done. The plants were then about six to eight inches high. Plot No. 1 received five applications of copper lime dust at intervals of ten days to two weeks, the last application being given on September 6. Plot No. 2 received four applications of Bordeaux (4 pounds bluestone, 8 pounds hydrated lime and 40 gallons of water) at intervals of ten days to two weeks. The last spraying was given on August 20. Plot No. 3 was not treated with a fungicide but was sprayed three times with calcium arsenate to control the potato beetles. An insecticide was also used in the first three applications of dust and Bordeaux on plot 1 and plot 2 respectively. The results obtained were as follows: 291 bushels per acre from the plot sprayed with Bordeaux; 255·5 bushels per acre from the plot dusted with copper lime dust; 194·5 bushels per acre from the plot left unsprayed as a check. The increase in yield in the sprayed and dusted plots was owing to the fact that the tops were protected by a fungicide from late blight and rot, which destroyed early in the season the foliage on plot No. 3 which was not treated with a fungicide.

On June 8, 1929, three plots of Green Mountain potatoes were planted and the first spraying and dusting was done on July 2 when the plants were from four to six inches high, and five applications of both spray and dust were made at intervals of two weeks, the last being made on August 10. Liquid Bordeaux (4 pounds bluestone, 8 pounds hydrated lime and 40 gallons of water), and copper lime dust were the fungicides used. A power sprayer was employed to apply the Bordeaux spray and a hand duster to apply the copper lime dust. The weather during July and August was very dry and no late blight and rot or other fungus diseases developed in any of the plots. When the plots were examined at the end of the first week of September, the potatoes in the check plot, that was neither sprayed nor dusted with a fungicide, but sprayed twice with an insecticide only (arsenate of lime) were so badly affected with tip burn that the tops were brown and practically dead, whereas the tops of the potatoes in the sprayed and dusted plots were quite green.

The results obtained this year were as follows: plot sprayed with liquid Bordeaux yielded 235 bushels per acre of marketable potatoes; plot dusted with copper lime dust 193 bushels per acre of marketable potatoes; check plot sprayed to control potato beetles only, 156 bushels per acre of marketable potatoes. This year the spraying and dusting both apparently had a marked effect in preventing tip burn and keeping the tops green for a long period of time, and hence increased the yields. It is possible that the results from the copper lime dust might have been better if a power duster had been used.

Summarizing the two years' results, both years (1928 and 1929) dusting and spraying markedly increased the yield of potatoes. The liquid Bordeaux gave better results than the copper lime dust in both years. As has already been pointed out, it is just possible that if the copper lime dust had been applied with a high pressure power duster, the results obtained might have been better. In the first year (1928), the increased yields obtained from the sprayed and dusted plots appear to be owing to the fact that the tops were protected by a fungicide against late blight and rot. This year (1929), there was no late blight and rot in any of the plots, but the liquid Bordeaux and the copper lime dust apparently prevented the development of tip burn, and kept the tops green long after those in the check plot were brown and dead, and thus increased the yields. In both years a profitable increase in yields has been obtained from spraying and dusting. The results obtained in 1929 are of special interest because they indicate that profitable increases in yields of potatoes may sometimes be obtained from spraying and dusting even in a season when weather conditions are such that late blight and rot and other diseases do not develop. (J. E. Howitt, *Ontario Agricultural College, Guelph, Ont.*)

FACTORS INFLUENCING THE CHARACTER OF BORDEAUX MIXTURE

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Ever since the report by Millardet (1) in 1885 that a suspension of lime and copper sulphate would effectively control downy mildew of grapes, this fungicide, later known as Bordeaux mixture, has continued to hold an important place in plant disease control. From time to time claims have been made that Bordeaux mixture may be improved by special methods of preparation and by the addition of substances classified as spreaders and adhesives. There is no general agreement as a consequence of these claims, hence, the authors have again examined the character of the Bordeaux mixtures as influenced by methods of preparation and by the addition of spreaders and adhesives.

Experimental

Preparation of Bordeaux.—To determine the influence of different methods of preparation upon the character of Bordeaux, samples were placed in test-tubes of uniform bore, and the rate of settling of the solids was recorded. We assumed that the rate of settling would be slower as the method of preparation approached the ideal owing to the inverse relationship between the rate of settling and the degree of dispersion. The ideal spray is probably one in which the solids are in a state of maximum dispersion. In table I, the time in minutes is recorded for the sprays prepared in different ways to settle 1·5 cm. in 6·5 cm. of liquid. The data presented are the results obtained with neutral Bordeaux containing 1·5 anhydrous lime (CaO) to 5 g. copper sulphate ($CuSO_4 . 5H_2O$). Tests showed that such a mixture gave no trace of the free copper ion.

TABLE I.—TIME TAKEN TO SETTLE BY SPRAYS PREPARED IN DIFFERENT WAYS

Mixture number	Method of mixing	Time in minutes to settle 1·5 cm.		
1	Cold CaO (1·5 : 150) added slowly to cold $CuSO_4 \cdot 5H_2O$ (5 : 150)	49	27	27
2	Cold CaO (1·5 : 150) added rapidly to cold $CuSO_4 \cdot 5H_2O$ (5 : 150)	98	99	91
3	Cold $CuSO_4 \cdot 5H_2O$ (5 : 150) added slowly to cold CaO (1·5 : 150)	146	109	130
4	Cold $CuSO_4 \cdot 5H_2O$ (5 : 150) added rapidly to cold CaO (1·5 : 150)	102	79	78
5	Hot CaO (1·5 : 150) added slowly to cold $CuSO_4 \cdot 5H_2O$ (5 : 150)	16	32	15
6	Hot CaO (1·5 : 150) added rapidly to cold $CuSO_4 \cdot 5H_2O$ (5 : 150)	52	38	62
7	Hot $CuSO_4 \cdot 5H_2O$ (5 : 150) added slowly to cold CaO (1·5 : 150)	105	87	81
8	Hot $CuSO_4 \cdot 5H_2O$ (5 : 150) added rapidly to cold CaO (1·5 : 150)	65	45	45
9	Hot CaO (1·5 : 150) added rapidly to hot $CuSO_4 \cdot 5H_2O$ (5 : 150)	6	17	16
10	Hot $CuSO_4 \cdot 5H_2O$ (5 : 150) added rapidly to hot CaO (1·5 : 150)	24	11	6
11	Cold $CuSO_4 \cdot 5H_2O$ (5 : 50) added rapidly to cold CaO (1·5 : 250)	86	61	75
12	Cold CaO (1·5 : 250) added rapidly to cold $CuSO_4 \cdot 5H_2O$ (5 : 50)	68	—	—
13	Hot $CuSO_4 \cdot 5H_2O$ (5 : 50) added rapidly to cold CaO (1·5 : 50)	43	—	—
14	Hot CaO (1·5 : 250) added rapidly to cold $CuSO_4 \cdot 5H_2O$ (5 : 50)	14	—	—
15	Cold CaO (1·5 : 50) added rapidly to cold $CuSO_4 \cdot 5H_2O$ (5 : 50)	4	—	—
16	Cold $CuSO_4 \cdot 5H_2O$ (5 : 50) added rapidly to cold CaO (1·5 : 50)	6	—	—
17	Cold $CuSO_4 \cdot 5H_2O$ (5 : 250) added slowly to cold CaO (1·5 : 50)	130	151	135

It is apparent from the data in table I, that the slower the reaction between the copper sulphate and the lime the more highly dispersed is the resultant complex. This is indicated by the greater time required for mixtures 3 and 17 to settle in comparison with the others. Therefore, it would appear that the best conditions for mixing Bordeaux are (1) when the reacting solutions are as cold as possible, (2) when the copper sulphate solution is poured slowly into the lime suspension rather than conversely, and (3) when the copper sulphate is as dilute and the lime suspension as concentrated as practical considerations permit.

Most horticulturists are familiar with point (1), the advantage of keeping the reacting mixture as cold as possible, but they are not so familiar with points (2) and (3). It is common practice to pour a dilute lime suspension into a concentrated copper sulphate solution. Although advocated by Pickering (2) as the ideal method of mixing, all our evidence points to the reverse process as the ideal one.

The above experiment was repeated using equal proportions by weight of copper sulphate and lime, the usual formula for alkaline Bordeaux. The data are not presented, for like the neutral Bordeaux, the best physical condition was obtained on mixing a cold dilute copper solution with a cold concentrated lime suspension.

It is generally supposed that an excess of lime tends to prevent burning although this is not confirmed by the investigations of Adams (3). However, a mixture of equal proportions of lime and copper sulphate is probably the safest for ordinary use owing to the variable CaO content of commercial lime. There is no doubt that burning will take place if sufficient lime is not present to completely neutralize all the copper sulphate. Equal quantities of lime and copper sulphate allow for a large margin of safety.

We found that the physical state of alkaline Bordeaux was slightly superior to that of neutral, as indicated by the slower rate of settling of the solids in the former. This is in agreement with the investigations of Card (4) who found that a high percentage of lime insured a more uniform spread. We did not confirm the conclusions of Wilmer and Kalberer (5) who claim that an excess of lime increases the adhesiveness of Bordeaux. Little difference was observed. In general, alkaline compared with neutral Bordeaux films appeared to be removed from leaves with slightly greater ease by both rubbing and washing.

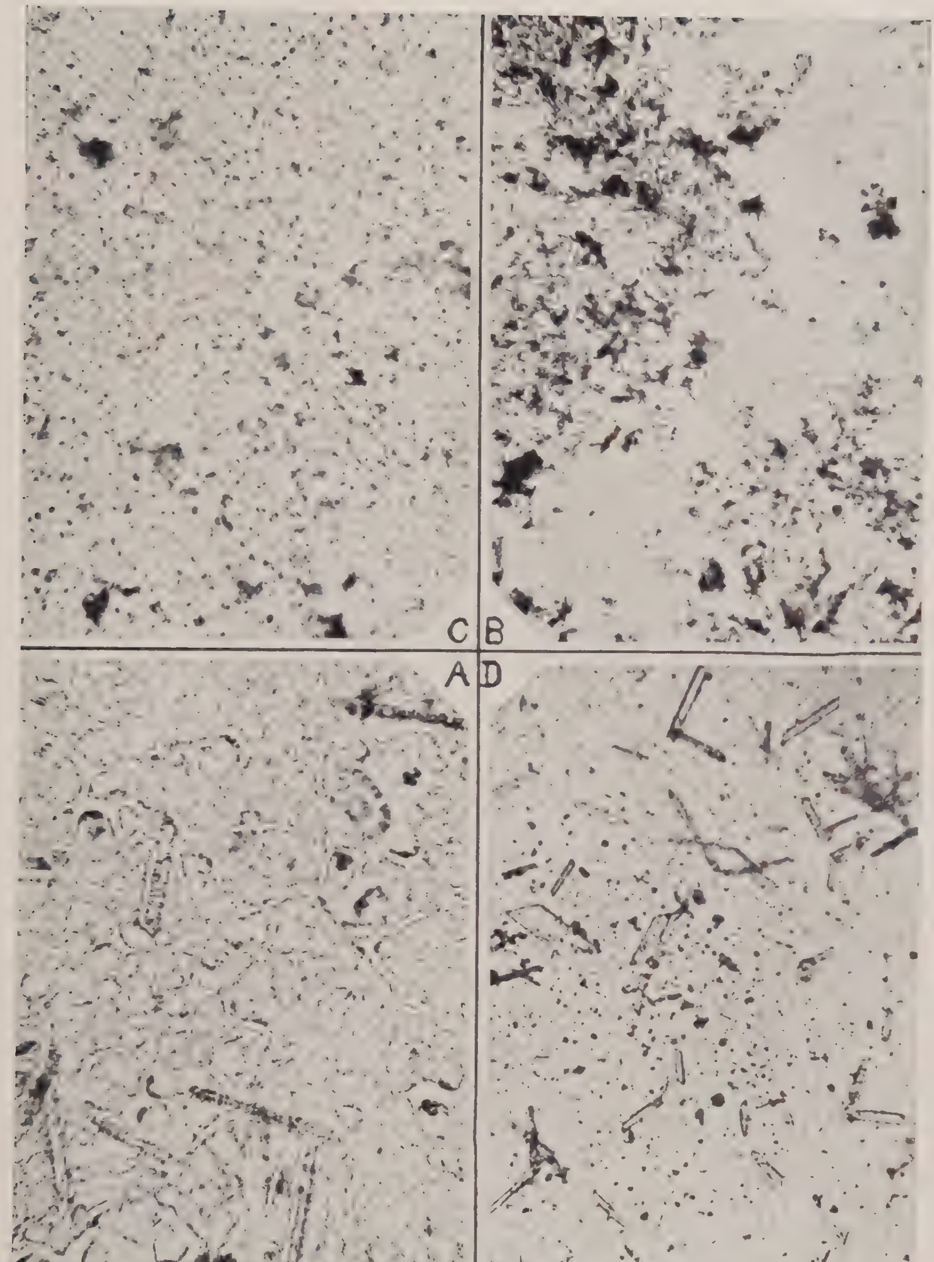
Bordeaux as Influenced by Spreaders and Adhesives.—The addition of spreaders or adhesives to Bordeaux has not been greatly urged. Probably the calcium caseinate spreaders are used more frequently than any others. Although claims are advanced (6 and 7) that through their use there are appreciable reductions in the required amount of spray, there are others (8 and 9) who believe that they do not justify their cost.

The rate of settling of the solids in Bordeaux was found at the outset to be an insufficient basis upon which to predict the relative value of the spreaders and adhesives. The following substances are discussed somewhat in their order of merit when added to both neutral and alkaline Bordeaux, beginning with the poorest, as based upon our investigations.

Sodium Silicate.—When sodium silicate was added to the lime suspension before mixing, the physical state of the resultant Bordeaux was inferior to normal as judged by the slightly more rapid rate of settling; but when 0·48 per cent was added to the mixed spray or to the copper sulphate solution, the resultant sprays were apparently much superior to normal for the rate of settling was many times slower than normal. However, after spraying upon leaf and clean glass surfaces, an examination of the dry film revealed a network of cracks as shown in Plate I.A. We believe this influence is sufficient to condemn sodium silicate as a spreader.

Fresh Skim-milk.—At concentrations of from 1 to 5 per cent fresh skim-milk seemed to improve the physical condition of Bordeaux as indicated by the slightly slower rate of settling and by the tendency of the spray so treated to spread a little better compared with normal when sprayed upon leaf and clean glass surfaces. However, upon drying, the films not only cracked badly but they had a tendency to flake off. The cracked and instable character of the dry film is probably a sufficient basis to condemn fresh skim-milk as a spreader for Bordeaux.

PLATE I.



A. Bordeaux film as influenced by 0·48 per cent sodium silicate showing network of cracks.
B. Bordeaux film as influenced by 0·05 per cent methyl alcohol showing the separation of the copper complex.
C. Bordeaux film as influenced by 0·15 per cent gelatine showing the inhibition of crystal formation.
D. Normal Bordeaux film showing the formation of large crystals of calcium sulphate.

Alcohols.—Substances that lower the surface tension of the spray would tend to promote better spreading of the spray particles. Likewise, better spreading and adhering might be brought about through the addition of substances soluble in the cutin of the leaf surfaces. It seemed probable that this dual role would be fulfilled by the alcohols. The following alcohols were tested; methyl, ethyl, caprylic, butyl and iso-amyl at concentrations ranging from 0·05 to 0·5 per cent. The actual leaf surface wetted by the spray was increased by these alcohols, but an undesirable separation occurred of the copper complex from the rest of the spray. This occurred both upon leaf and clean glass surfaces. The edges of the film formed by each droplet were colourless and contained no appreciable amounts of copper. This is illustrated by Plate I.B. The dark spots consist of the separated copper complex. This unequal distribution of copper is undoubtedly undesirable. Since normal Bordeaux shows little tendency for the copper complex to separate when sprayed upon leaf and glass surfaces, there is probably no advantage in using any of these alcohols as spreaders.

Wheat Flour.—The addition of 0·15 per cent wheat flour added in the form of a thin paste did not noticeably influence either the physical character of the Bordeaux or the character of the dry film. At higher concentrations, namely, 0·5 per cent cracking and peeling off of the dry film occurred. There is apparently no advantage in using wheat flour as an adhesive or spreader.

Agar.—Compared with normal Bordeaux, the addition of 0·15 to 0·3 per cent agar caused a slightly more rapid sedimentation of the solids, an undesirable effect, and we failed to observe any change in the permanence or other characters of the dry film through the addition of agar.

Calcium Caseinate.—The addition of 0·15 to 0·5 per cent calcium caseinate did not perceptibly alter the physical condition of the Bordeaux as indicated by the rate of sedimentation. It appeared to induce slightly better spreading when sprayed upon leaf and clean glass surfaces. There was a tendency for the copper complex to separate but only to a slight degree compared with the alcohols. The dry film upon leaf and glass surfaces withstood mechanical rubbing and washing slightly better than those of normal Bordeaux. On the other hand there was a slightly greater tendency of the Bordeaux-calcium-caseinate films to crack. The total evidence suggests that this spreader has a small value. The best physical condition was obtained when calcium caseinate was added to the mixed spray rather than to either components.

Gelatine.—At concentrations of 0·15 to 0·3 per cent the rate of sedimentation of the Bordeaux was not significantly altered if the gelatine were added to the mixed spray. If added to either the lime suspension or to the copper sulphate solution before mixing, the gelatine had an unfavourable effect. It caused the solids to settle out more rapidly than occurred with normal Bordeaux. The advantage of adding gelatine to the mixed spray was revealed in the character of the wet and dry films when sprayed upon leaf and glass surfaces. It appeared to induce a more uniform distribution of the copper complex. The dry film was also more resistant to mechanical rubbing and washing than that of normal Bordeaux. The gelatine inhibited the formation of calcium sulphate crystals. This may be seen by comparing the photograph of the film containing 0·15 per cent gelatine, Plate I.C., with that of normal Bordeaux, Plate I.D. This inhibition of crystal formation would probably tend to make the film more resistant to weathering. Our evidence appears to indicate that there are definite advantages of adding 0·15 per cent gelatine to mixed Bordeaux as a spreader or adhesive.

Common Soaps.—The addition to Bordeaux of 0·15 per cent whale oil soap or the same quantity of the common brands of household soaps created undesirable curds. Although the formation of these curds is sufficient to condemn common soaps in general as spreaders, these experiments proved that the quantity of curd varied with the brand of soap. With one brand called "Crystal White" little curd was produced, and when added to Bordeaux the spread and permanence of the film was slightly better than that induced by any of the spreaders above described.

Potassium-Resin-Soap.—Very satisfactory results were secured with "Potassium-resin-soap" prepared by boiling together 2 parts resin, 1 part potassium hydroxide and 3 parts water by weight. This soap at a concentration of 0·15 per cent decidedly improved the physical condition of the Bordeaux as indicated by the longer time required for the solids to settle, and by the character of the wet and dry film formed when sprayed upon leaf and glass surfaces. The film spread well and there was no tendency for the copper complex to separate. The dry film also appeared to be more resistant to mechanical injury by rubbing and to the effect of water than those induced by any other spreader or adhesive that was tested. Since potassium-resin-soap can be manufactured quite cheaply we believe that it has considerable promise as a spreader or adhesive for Bordeaux.

Sodium-resin-soap did not behave in a similar manner. It affected adversely the physical character of the Bordeaux by causing the solids to settle out more rapidly, and when sprayed upon leaf and glass surfaces, the film had no superior characters over that of normal Bordeaux. It was prepared and used in exactly the same manner except that sodium carbonate replaced potassium carbonate.

Potassium-resin-soap gave the best results in our field tests. Hop vines were sprayed with Bordeaux containing different spreaders. Hop leaves seemed particularly suitable to study the efficiency of spreaders, for with Bordeaux alone the coverage on the under surface of the leaves was seldom satisfactory. The comparative efficiency of the spreaders was determined also by dipping excised hop leaves in Bordeaux with and without spreaders, and examining the leaves under a low power microscope when the Bordeaux films were dry.

SUMMARY

(1) Based upon the assumption that the solids of Bordeaux settle more slowly as the physical condition approached the ideal, it appeared that the best method of preparation was to pour slowly a dilute copper solution into a concentrated lime suspension when both solutions were as cold as possible.

(2) No evidence was obtained that alkaline Bordeaux adhered to foliage better than neutral Bordeaux but the physical character of alkaline Bordeaux was somewhat superior.

(3) The addition of sodium silicate, fresh skim-milk and several alcohols appeared to exert a harmful influence.

(4) Little significant effect were detected through the addition of wheat flour and agar.

(5) The addition of calcium caseinate appeared to improve slightly the spread of the wet and the permanence of the dry film when sprayed upon leaf and glass surfaces.

(6) The addition of whale oil soap and ordinary washing soaps with one exception caused an undesirable curd to appear. The addition of potassium-resin-soap appeared to exert a favourable influence. The degree of dispersion

of the solids in the spray and the spread and the permanence of the film formed upon leaf and glass surfaces appeared to be improved. On the other hand no beneficial influence could be detected through the addition of sodium-resin-soap.

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A ROOT-ROT OF SWEET CLOVER AND RELATED CROPS CAUSED BY *Plenodomus Meliloti* DEARNESS and SANFORD, nov. spec.

(ABSTRACT)

A destructive root rot of sweet clover *(Melilotus)*, common clover *(Trifolium)* and alfalfa *(Medicabo)* was described and proof given that the disease was caused by *Plenodomus Meliloti* D. and S. n. sp. The causal fungus was described and the morphology of its pycnidium shown. The minimum, optimum and maximum temperatures for growth were found to be about 1° C., 15-16° C. and 26-27° C. respectively. The necrotic lesions develop early before the roots recover from the dormant condition. (G. B. SANFORD, *Dominion Plant Pathological Laboratory, Edmonton, Alberta.*)

NOTES ON SEXUALITY IN *Fomes pinicola* (Sw.) COOKE, *Fomes roseus* (Fr.) COOKE, *Polyporus Tuckahoe* (GÜSSOW) SACC. ET TROTT., *P. resinosus* (SCHRAD.) Fr., *P. anceps* PECK, *Lenzites saepiaria* Fr., *Trametes protracta* Fr., and *T. suaveolens* (L.) Fr.

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During the past year monosporous mycelia of several different species of wood-destroying fungi have been isolated as opportunity offered. Pairings have been made, and a summary of the results is given here, although it is recognized that much of the work is either incomplete, or requires confirmation—conditions which will be rectified as new material becomes available.

Fomes pinicola.—I have reported elsewhere* the results obtained with *Fomes pinicola* when monosporous mycelia from one fruit-body were paired with monosporous mycelia from fruit-bodies from different localities. Clamp-connections were formed in practically every pairing except those with monosporous mycelia from a culture (No. 562C) from British Columbia. Since then monosporous mycelia have been obtained from a second culture from Stockholm. They have been paired with monosporous mycelia from the first Stockholm culture and with others from a number of sources, e.g. York Mills and Timagami, Ont., Fredericton, N.B., Vancouver, B.C., and France. As before clamp-connections were formed in all pairings except those with culture No. 562C from British Columbia.

Previously, the presence of clamp-connections on a mycelium had been taken as a sign that the nuclei occurred in pairs. This summer, Miss Mildred Nobles, while working in this laboratory, was able to demonstrate by means of stained preparations that in *Fomes pinicola* and in *Polyporus Tuckahoe* there is a single nucleus in each cell of a mycelium of monosporous origin, and a pair of nuclei which divide conjugately in each cell of a mycelium bearing clamp-connections.

Fomes roseus.—Monosporous mycelia were isolated from three sporophores from different sources. Pairings showed that, in the forms studied, this species is heterothallic and bisexual, and that monosporous mycelia from one source were completely cross-fertile with those from each of the other sources.

Polyporus Tuckahoe.—Cultures of this fungus were obtained from the centre of a sclerotium. Sporophores developed in several flask cultures containing poplar twigs embedded in malt agar.† Twenty-three monosporous mycelia were isolated from one of these sporophores almost a year ago, and they have remained in the haploid condition. Pairings have been made and clamp-connections were found in a number of them, so that this species is heterothallic, but repeated trials have failed to show definitely whether it is bisexual or quadrisexual.

Lenzites saepiaria and *Trametes protracta.*—Some workers consider *Trametes protracta* to be merely a pored form of *Lenzites saepiaria* but Weir, Faull, and Snell consider it a distinct and valid species.‡

Monosporous mycelia were isolated from a sporophore of *Lenzites saepiaria* collected at Timagami, Ontario. A series of all possible pairings showed that this species is heterothallic and bisexual. Similar pairings of mycelia from a second sporophore from Timagami and one from Cranberry Lake, N.Y., confirmed these results.

In the same way monosporous mycelia were obtained from a sporophore of *Trametes protracta* collected in British Columbia by Mr. Mielke and from one collected at Timagami, Ontario. Series of all possible pairings showed that this species, too, is heterothallic and bisexual.

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* Mounce, Irene. Studies in Forest Pathology II, The Biology of *Fomes pinicola* (Sw.) Cooke. Dom. Can. Dept. Agr., Bull 111 n.s., pp. 39-44, 1929.
† Rept. Dom. Bot. Ottawa, 1928.
‡ For references and a more detailed account see Rept. Dom. Bot. Ottawa, 1928.

Then monosporous mycelia of *Lenzites saepiaria* from one source were shown to be mutually fertile when paired with those from the other sources; similar results were obtained with *Trametes protracta*. On the other hand, although 169 pairings have been made using material from five sources, no clamp-connections have been found so far in pairings of any monosporous mycelium of *L. saepiaria* with any monosporous mycelium of *T. protracta*. Such evidence, though not conclusive, strongly supports the view that *T. protracta* is distinct from *L. saepiaria*.

Trametes suaveolens.—A culture was obtained from infected wood of a willow branch on which a sporophore of *T. suaveolens* had developed, and the mycelium was identified by comparison with the stock culture. From a sporophore which developed on malt agar, twenty monosporous mycelia were isolated. Unfortunately, it was not possible to examine these mycelia until almost three months later. By that time clamp-connections were abundant on every mycelium. Since then one monosporous mycelium has developed a pored surface and has shed spores. Sown *en masse* these spores produce within a week a mycelium with numbers of clamp-connections. These facts are taken as strong indications that *T. suaveolens* is a homothallic species.

Polyporus resinosus.—Spores were obtained from a culture made from the context of a sporophore which grew on birch. Eight monosporous mycelia were isolated, and two weeks later, the mycelium in each culture bore numerous clamp-connections. This species is, therefore, considered to be a homothallic one.

Polyporus anceps.—A specimen of rot in western yellow pine *(Pinus ponderosa* Dougl.*)* was received from British Columbia. Mycelium was isolated from it and identified as that of *Polyporus anceps* by comparison with the stock culture. Monosporous mycelia were isolated from a fruit-body which developed in culture. A series of all possible pairings showed that this fungus is heterothallic and bisexual. Then these monosporous mycelia were paired with those isolated from the stock culture of *P. anceps*. Clamp-connections were formed in every pairing and thus, by the clamp-connections criterion for identity of species, the original identification was confirmed.

PRELIMINARY STUDY ON THE HYBRIDIZATION OF PHYSIOLOGIC FORMS OF *Puccinia Graminis Tritici*

(Abstract)

Pustules of monosporidial origin were obtained by inoculating individual barberry plants with sporidia produced by telia of a number of single physiologic forms of *Puccinia graminis* Pers. var. *tritici* Erickss. and Henn. The telia of each form had developed under controlled conditions.

The nectar on the pustules derived from the same physiologic form was intermixed ("selfing" individual forms), as was also the nectar on pustules derived from two different forms ("crossing" two forms). Only one form appeared strictly homozygous for pathogenicity; when "selfed," this form alone was recovered. The other forms appeared heterozygous for pathogenicity; when "selfed," each gave rise to one or more different forms, either previously known or hitherto unknown. From crosses between two forms, there arose forms differing from the parental ones, some previously known, others hitherto unknown.

From a reciprocal cross between two forms, a third form alone was recovered.

Barberry plants were inoculated with eight forms *en masse*. Monosporidial pustules from each of the eight forms may be supposed to have developed. Some of these pustules coalesced and produced aecia. The nectar of the remaining ones was intermixed. From these inoculations were recovered several of the original forms and a number of other forms, some previously known, others hitherto unknown. (Margaret Newton, T. Johnson and A. M. Brown, *Dominion Rust Research Laboratory, Winnipeg, Man.*)

A FUSARIUM DISEASE OF THE CUCUMBER FRUIT

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This paper is a preliminary report of investigations of a disease of the cucumber, *Cucumis sativus* L., which made its appearance in the greenhouse of the Horticultural Experiment Station at Vineland, Ont., during the month of June, 1929. The author has been unable to find any previous description of this disease in the literature available in this connection. The disease was very severe on the susceptible varieties of its host, involving a loss of upwards of 40 per cent of the marketable produce with rapidly increasing proportions which were avoided only by the adoption of adequate control measures. Soon after the disease had been first observed investigations were undertaken to determine its nature and cause, and subsequently to study the parasitic and taxonomic relationships of the causal organism.

SYMPTOMS.—The disease has so far manifested itself only on the fruit. Leaves, stems and other organs of the plant appear to be free from any lesions or abnormal development. The first evident symptom is a slightly discoloured area on the young fruit which presents a water-soaked appearance. Closer examination reveals an irregular, slightly sunken, olive-green lesion contrasting sharply with the surrounding healthy parts of the fruit. Numerous minute droplets of a gummy exudate cover the surface of the lesion frequently coalescing to form conspicuous transluscent globules (plate II.A). These later become amber-coloured assuming a solid state and persisting on the lesion as a film. As the fruit enlarges the film of gum cracks irregularly, thus presenting a mesh-work of fissures which give to the fruit a scabrous appearance. The lesions frequently extend for more than three-quarters the length of the fruit on one side, and the mature fruit is invariably curved and distorted due to the restricted growth in the region of the lesion and the more or less normal development of the unaffected portion (plate II.B). In a few instances splitting of the normal parts of the fruit occurred in the vicinity of the affected areas. The lesion is entirely superficial and has not been observed to extend beyond the epidermal layer of the fruit.

CAUSE OF THE DISEASE.—A species of *Fusarium* was found to be constantly associated with the disease lesions. This organism was obtained in pure culture on potato dextrose agar and on sterile cucumber tissue, and the disease was readily reproduced by artificial inoculations under controlled conditions with the development of typical lesions from which the fungus was re-isolated.

The causal organism is a fungus belonging to the genus *Fusarium* Link, and, pending further studies, will be placed under the section *Ventricosum* Wr. It is a wound parasite, being unable to establish parasitic relationships through natural openings or by penetrating the unbroken epidermis of the host.

PREDISPOSING FACTORS.—From the preliminary examination of the disease in the greenhouse it was observed that the lesions were always located on such portions of the fruit as had been in contact with leaves, stems, or the trellis wires which supported the vines. Abrasion of the young and tender fruits from these contacts is quite obvious especially when it is remembered that the organs of the plant mentioned are provided with innumerable stiff bristles. In this manner, therefore, is the infection court prepared for the inoculum.

Conditions of high temperature and high humidity are particularly favourable to infection and to the progress of the disease. The common practice of forcing growth by raising the temperature of the greenhouse and watering freely would appear to provide ideal conditions for the development of the pathogen. Copious production of gum and by far the most extensive lesions occurred under conditions of high temperature and atmospheric moisture.

Plate II.

A. Early symptoms. Note the formation of gum globules in the area of the lesions. Note also the absence of gum from the uninoculated wound near the flower end of the larger fruit.

B. Later symptoms. Mature diseased fruits to illustrate the scabrous appearance, distortion, and occasional splitting produced. Such fruits are unsaleable.

Varietal Susceptibility.—Only the smooth skin varieties have been observed to suffer natural infection, the rough skin varieties being somewhat resistant if not altogether immune. The outbreak of this disease occurred on plants with which hybridization studies were being conducted. The English "Forcer," a smooth skin variety was crossed with one of the rough skin varieties. Both the smooth skin parent variety and the smooth skin F_2 offspring were very susceptible, especially the latter. The rough skin F_2 offspring, however, exhibited resistance or immunity in much the same way as the original rough skin parent variety.

A cytological examination of the tissues revealed the fact that the three outermost layers of the cortex in the rough skin variety were made up of sclerenchymatous tissue which is in marked contrast to the thin-walled parenchyma of the susceptible varieties. To what extent this will explain the question of resistance and susceptibility may be determined by further study.

Control.—This phase of the investigation was not followed in detail. From the outset a reduction of the temperature and atmospheric humidity of the greenhouse was recommended with the result that within three weeks the disease was effectively under control, only an almost negligible number of the fruits being affected. This measure therefore suggests its use as a practicable and effective means of control.

Since the rough skin variety has proven to be highly resistant or immune, it is suggested that this variety be used in place of the smooth skin variety wherever the disease is very prevalent.

Greenhouse fumigation after cropping is frequently practised and this should be useful in reducing the sources of inoculum.

The occurrence of this disease might well be borne in mind by those engaged in hybridization work with cucumbers. There is an increasing demand on the market for a smooth skin type of fruit free from the conspicuous wart-like protuberances of the rough skin variety but with the convenient packing size of the latter. It is with this end in view that Mr. W. J. Strong of the Experiment Station conducted the hybridization experiments already referred to.

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* The author is greatly indebted to Dr. D. L. Bailey and to Mr. W. J. Strong, of the Horticultural Experiment Station, for their kind co-operation which made the investigations possible.

THE INFLUENCE ON YIELD AND GRADE OF HARVESTING RUSTED MARQUIS WHEAT AT DIFFERENT STAGES OF MATURITY

(Abstract)

Field experiments were made in Manitoba in 1927, 1928, and 1929, to determine the effect of harvesting rusted Marquis wheat at different stages of maturity on the yield and quality of the grain.

In 1927, under conditions of a severe natural epidemic of leaf and of stem rust, Marquis wheat was harvested eighteen, twelve, and six days before, and at maturity, in the districts of Morden, Thornhill, Graysville and Winnipeg. At Winnipeg in 1928, a diseased crop was cut at the following stages: twelve, nine, six, and three days before, and at maturity. In 1929, under an artificially induced epidemic of stem rust representative samples of wheat were cut at intervals of two days beginning on August 7 and ending at maturity (August 21). In each year, the yield data were studied statistically and the weight per bushel, 1,000-kernel weight, percentage of green kernels, and grade, were determined for each date of cutting.

In 1927, 1928 and 1929, cutting rusted wheat before it was fully mature significantly reduced the yield. Grain quality, as indicated by weight per bushel and 1,000-kernel weight, was markedly improved when the plants were permitted to mature before harvesting; while the percentages of green and shrunken kernels were reduced. In 1927 and 1929 particularly, stem rust developed rapidly and its destructiveness increased as the wheat approached maturity. Under these conditions, yield and quality of wheat harvested prematurely were significantly less than the yield and quality of the more heavily rusted wheat harvested at the normal time.

In each year, yield per acre, weight per bushel, and grade of wheat harvested at early stages were less than in fully matured grain. From the kernel weight results, it was apparent that little or no filling of the grain occurred after cutting.

The results obtained in 1927, 1928 and 1929, distinctly show that in order to secure the largest yield and best quality of grain, rusted wheat should be harvested when the majority of the kernels are in the hard dough condition. (F. J. Greaney, *Dominion Rust Research Laboratory, Winnipeg, Man.*)

THE RELATION BETWEEN STEM RUST INFECTION AND THE YIELD OF WHEAT

(Abstract)

Two experiments are described in which varying amounts of stem rust on plots of Marquis wheat are obtained by different treatments with sulphur dust. Rust percentages and yields of individual plots were then correlated.

The first experiment consisted of 196 1/400th-acre plots arranged in a 14 by 14 latin square. The average percentage of rust was not very high but a correlation coefficient of $-\cdot 4143$ was obtained between rust percentage and yield. The odds of significance of this correlation are considerably greater than 100 to 1. By means of the regression equation it was shown that each 10 per cent increase of rust brought about a reduction in yield of $1\cdot 97$ bushels per acre, or $6\cdot 8$ per cent of the yield of the best yielding series.

In the second experiment there were 113 1/200th-acre plots in which the average percentage of rust was somewhat higher than in the first experiment. A correlation of $-\cdot 6085$ was obtained for yield and percentage of rust. Each 10 per cent increase of rust reduced the yield by $3\cdot 83$ bushels which is $9\cdot 7$ per cent of the yield of the highest yielding series.

In both cases regression was linear showing that the decrease in yield for a given increase in the rust percentage is the same throughout the entire range of infection. (C. H. Goulden and F. J. Greaney, *Dominion Rust Research Laboratory, Winnipeg, Man.*)

ROOT AMPUTATIONS IN THE STUDY OF ROOT-ROTS OF CEREALS

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Introduction

Root-rot diseases rank as one of the major problems in the successful production of cereal crops. This is especially so in the growing of wheat. Fungous parasites which attack the subterranean parts of the plants cause some of our most common and destructive root diseases. In the case of wheat these fungi destroy all or part of the seminal root system, crown root system or the internode between, which will be referred to as the subcrown internode. It appears that the disease condition may be the result of actual loss or impairment of tissues, toxic substances produced by infections or both. It was thought that artificial injuries in the form of amputations would enable one to determine, relatively at least, the significance of the actual loss of certain organs or portions thereof.

Haberlandt (2) in speaking of extirpation experiments writes in part as follows:—

> "A mutilated organism generally 'makes shift' to the best of its ability and is often able to transfer the duties of an excised organ to a different structure, and in this way to carry on the threatened function, not indeed with unimpaired vigour, but still to such an extent that the organism as a whole manages to survive."

Locke and Clark (1) report some observations upon the development of winter wheat from seminal roots.

The writers wish to acknowledge the help received from Mr. W. G. Sallans and Mr. G. A. Scott who assisted with many of the tests.

Throughout the period of experimentation careful attention was given to the normal development of the wheat plant both under greenhouse and field conditions.

Development of the Wheat Plant

The general development of wheat throughout the season has been frequently described by various workers. In this work, however, it was necessary to obtain some records of the development under the conditions of Western Canada. In the field work of 1929, records were made at three week intervals on the growth of plants at Indian Head. The specimens used for these records were taken from rod rows sown three feet apart and consequently spacing brings in some irregularities. The seeds were sown approximately three inches deep and the plots were on summerfallowed land. The records are shown in Table I.

TABLE I.—SHOWING SOME RECORDS MADE UPON WHEAT PLANTS AT THREE WEEK INTERVALS DURING THE SEASON OF 1929 AT INDIAN HEAD

Date	Height of plants	Number of			
		Stems	Seminal roots	Crown roots	Heads
	cm.				
May 22	4	1	3	0	0
June 12	21	4	5	3	0
July 3	50	10	5	33	0
July 24	85	11	5	–	8
Aug. 14	88	11	5	59	8

From the above records one can see that at the end of the first three weeks the shoot was very short and only the first three seminal roots were functioning. At the end of six weeks there was a marked increase in growth, the shoot was 21 cm. in height with three tillers, five primary roots as well as three crown roots. Between the dates of June 12 and July 3 a great increase in growth took place, with the addition of six tillers and thirty crown roots, as well as a proportional increase in height. Eight tillers were headed on July 24. There was no increase in the number of primary roots after June 12. The spacing of the rows probably explains the rather large number of tillers and crown roots. The final three weeks was a period of ripening with very little increase in growth as measured by height or number of roots. As the seed were sown relatively deep there was a distinct subcrown internode. The rainfall throughout the season consisted largely of scattered showers which was beneficial to the establishment of crown roots (fig. 1.).

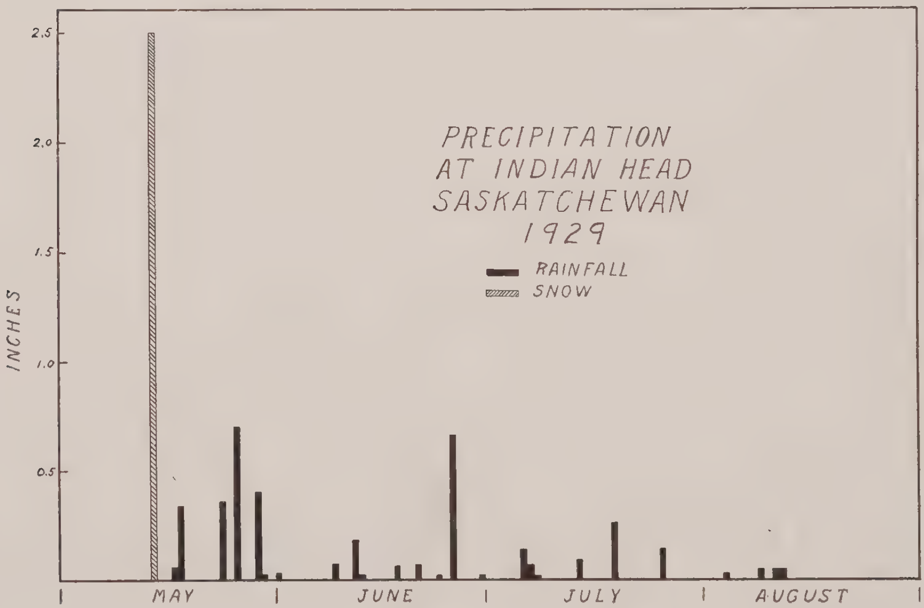

FIG. 1.—Chart showing precipitation at Indian Head, Sask., in 1929, during the period of field experimentation.

Preliminary Experiments

In some preliminary tests made in the field in 1926, it was found that severing the subcrown internode of wheat plants which were 25 to 30 cm. in height, produced a severe shock. Some of the tillers died and the new ones which were produced caused the plants to be distinctly late. Plants of a similar development which had two or three crown roots amputated did not show any noticeable injury. Under greenhouse conditions many preliminary operations were made upon seedlings. In every case, however, the general reactions were the same as recorded in the experiments below which are quite typical.

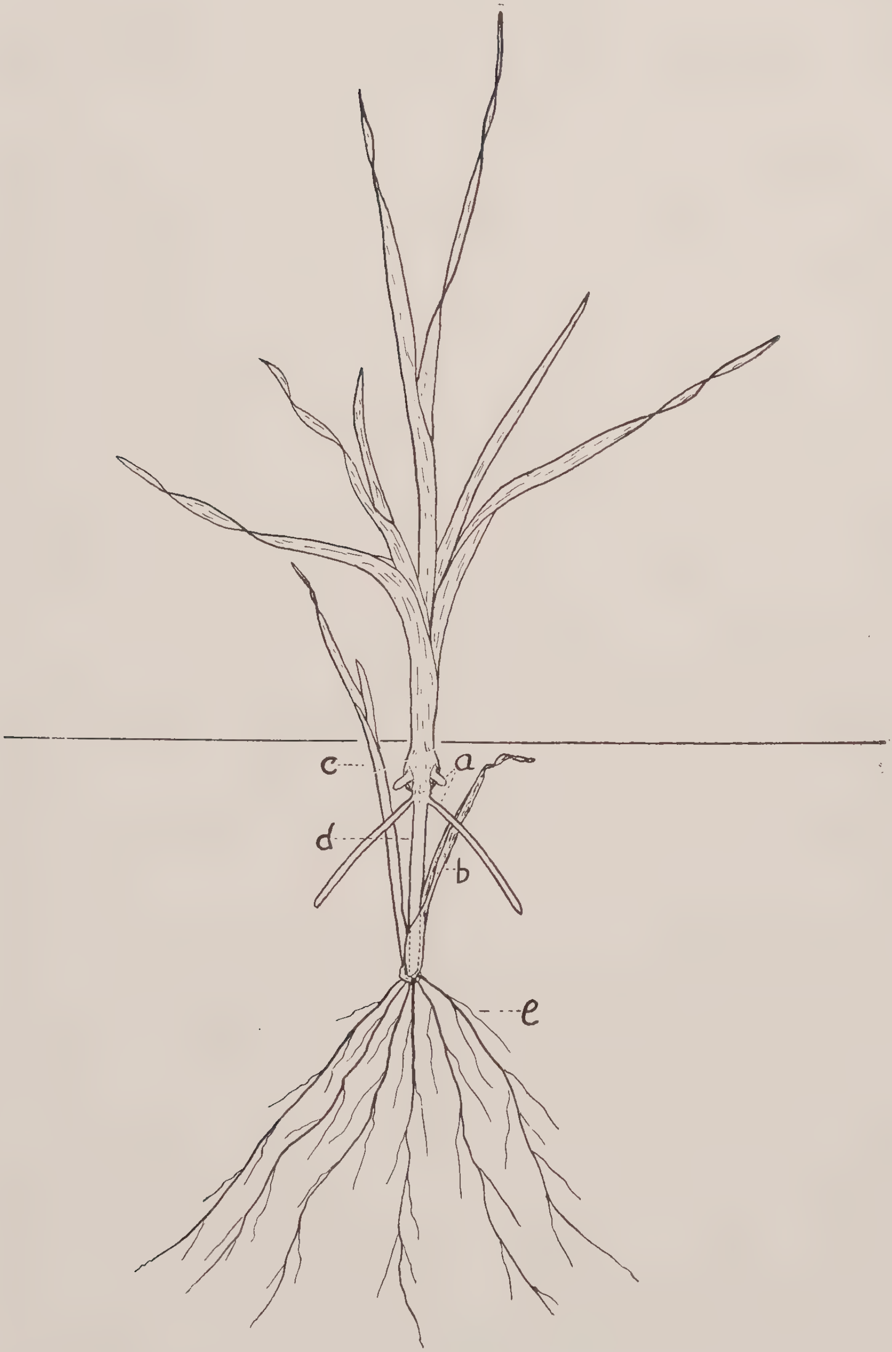

Fig. 2.—Diagram of a wheat seedling showing the principal parts: (a) crown roots; (b) coleoptile (c) tiller from the axil of the coleoptile; (d) subcrown intermode and (e) seminal roots.

The Effect of Seminal Root Amputations

These tests were conducted in the greenhouse. One gallon crocks were used and the soil moisture was maintained at approximately 50 per cent of the moisture holding capacity. The seeds were of good quality Marquis and were sown

usually three inches deep although other depths were tried. When the seedlings had developed to the desired stage, a small excavation was made to expose the part to be operated upon. After the operation the soil was carefully replaced. the reaction of the seedlings after each operation was carefully noted.

Exp. 1.—Seven seedlings were used in this test, three were sown at a depth of 1·5 inches and four at a depth of 3 inches.

At the end of one week those sown at 1·5 inches were 10 cm. in height, first leaf stage and with three seminal roots. At this time the seminal roots were cut off two of the seedlings.

One of these examined a week later showed no increase in height, however, a second leaf had appeared, as well as three new seminal roots.

The other seedling examined two weeks after the operation was 20 cm. in height, fourth leaf stage, one tiller, two small seminal roots, and three well developed crown roots with two more just starting.

The seedlings had recovered.

The check seedling at the end of three weeks was 23 cm. in height, fourth leaf stage, one tiller well developed, three good seminal roots and four strong crown roots with two starting.

Two of the remaining four seedlings were allowed to develop for two weeks before being operated upon while two served as checks. At this age the average development was 16·5 cm. in height, third leaf stage and 3·5 seminal roots. The seminal roots were cut off.

When one seedling was examined a week later there was no increase in height, the third leaf, however, was well developed, but the lower leaf was dead; the second pair of seminal roots and the sixth seminal root were well developed, as well as two crown roots just starting.

A check plant at this age was 20 cm. in height, fourth leaf stage, one tiller well developed, three strong seminal roots, two established crown roots with another starting.

The other seedling which had been operated upon was examined two weeks later when it was found that it was 20 cm. in height, fifth leaf stage, three new seminal roots including the sixth as well as four well established crown roots.

The seedlings had recovered in each case.

A check seedling when four weeks old was 24 cm. in height, fifth leaf stage, two tillers, three seminal roots and four crown roots all strongly developed.

It can be seen, that under the condition of these tests, seedlings one to two weeks old are able to recover after the seminal roots, then established, are cut off. There were in each case, however, manifestations of shock after the operation, such as no increase in height and temporary wilt symptoms. The seeding depth did not appear to affect the reactions. Seedlings up to two weeks old have as a rule three well developed seminal roots but no crown roots so that the remaining seminal roots are able to respond if the first ones are injured. By the end of three weeks crown roots appear and the seedlings are supported by these even if the entire seminal root system is destroyed. Only about one half or less of the total number of possible seminal roots support the seedling until crown roots are formed. Although measurements were not made it was thought from observations that injuries to the first roots caused an increase in the rate of growth and appearance of the crown roots. Mr. R. C. Russell working at this laboratory found that when the seminal root system was attacked by the fungus *Ophiobolus graminis*, crown root development was well in advance in comparison with check plants. The sixth seminal root which frequently does not appear, almost invariably does so when the first seminal roots are injured.

The Effect of Severing the Subcrown Internode

The general arrangement and technique were the same in this case as in the seminal root operations.

Exp. 2.—Five seedlings were used, two had the subcrown internode severed when two weeks old, two received the same treatment when three weeks old, and one seedling was uninjured.

At the end of two weeks the seedlings were on an average 15 cm. in height, third leaf stage and with three seminal roots. The subcrown internodes of two seedlings were severed at this stage. The seedlings never recovered and in a few days were dead.

The two seedlings which were operated upon at the end of three weeks were 21 cm. in height, fourth leaf stage, one tiller, three seminal roots and two crown roots.

One was examined a week later when it was found that there had been no increase in height and a lower leaf was dead. It had continued to develop, however, as there was one additional tiller and four new crown roots.

The other seedling was examined two weeks after the operation when it was found to be 30 cm. in height, seventh leaf stage (lower leaf dead), four tillers (three well developed) and eleven crown roots of which eight were well established.

The seedlings three weeks old were able to recover after their subcrown internodes had been severed.

A check seedling at the end of five weeks was 35 cm. in height, seventh leaf stage, five tillers (three well developed) also twelve crown roots and three seminal roots.

In the subcrown internode operations the shock results in death unless crown roots are established. Severing the subcrown internode completely cuts off the lower root system and the plant must rely upon the crown roots. Once the crown roots are established the subcrown internode and seminal roots may be destroyed without killing the plant.

The Effect of Amputating Crown Roots

The same general methods employed in the previous tests were used here.

Exp. 3.—Seven seedlings were studied in this test, two had their crown roots amputated when three weeks old and two at the age of four weeks. Three seedlings were used for checks.

By the end of three weeks the plants were 21 cm. in height, fourth leaf stage, three seminal roots, one tiller and three crown roots. The crown roots were amputated from two seedlings at this time.

One of these seedlings when examined a week later showed very little evidence of shock, it was 27 cm. in height, sixth leaf stage, four tillers (two well developed), seven crown roots (four well developed), and three good seminal roots.

The other seedling was examined two weeks after the operation when it was 35 cm. in height, seventh leaf stage, nine tillers (three well developed), twelve crown roots and four seminal roots.

The two seedlings which had the crown roots amputated at the end of four weeks were on an average 31 cm. in height, sixth leaf stage, five tillers (three well developed), three seminal roots and six crown roots.

One seedling examined one week after the operation was 32 cm. in height, seventh leaf stage, six tillers (three well developed), eight crown roots and three seminal roots.

The other seedling examined two weeks after the operation was 40 cm. in height, eighth leaf stage (three lower leaves dead), eight tillers (four well developed), fourteen crown roots and three seminal roots.

The seedlings showed very little shock in either case and continued to develop after the operation.

A check plant when six weeks old was 44 cm. in height, eighth leaf stage (lower leaf dead), ten tillers (four well developed), twenty crown roots, four strong seminal roots including the sixth.

It is apparent that under the conditions of these tests, the loss of two or three crown roots to a seedling three weeks old is quite insignificant. The seedlings quickly recover. Seedlings four weeks old received a greater shock because of the larger number of crown roots lost, but they soon recovered. In the last case it will be observed that the difference in number of crown roots between the check and treated plant at the end of six weeks was the number which had been cut off.

The Effect Upon Development to Maturity When the Underground Parts are Injured in the Seedling Stage

Exp. 4.—This experiment was a continuation of the greenhouse work. The same methods as used above were employed in making the operations and the plants were kept under observation to maturity.

Seedlings having their seminal roots amputated were from one to five weeks old, those having subcrown internodes severed were from two to six weeks old, and the crown roots were cut off seedlings from four to six weeks old.

Only a small number of plants could be observed in such a test but the observations can be summarized in a general way. The conclusions, however, are drawn from detailed records made each week from the time of operation to maturity. For the seminal root and subcrown internode cuts the shock was very noticeable, especially when the seedlings were less than three weeks old. After the short period of shock, however, the plants came along in fair comparison with the checks. The amount of shock shown when crown roots were amputated was in proportion to the number of roots lost. The plants which lost their crown roots when four weeks old headed at least a week earlier than any of the others.

The Influence of Amputations under Field Conditions

The object of these tests was to determine the influence upon the general development of wheat plants when the seminal roots, crown roots or subcrown internodes were amputated during the seedling period. The same technique as used in the greenhouse tests was applied here. It was found in preliminary trials that the slight disturbance of the soil prior to making the amputations was not in itself deleterious.

Exp. 5.—This test was conducted at Saskatoon in 1928. Rod rows were used and were planted three feet apart in order to have convenient working room. One hundred kernels of a very good quality Marquis were sown to a row. The seeds were evenly spaced and sown three inches deep. There were two rows for each type of amputation, namely seminal roots, crown roots and subcrown internodes with an appropriate number of check rows. The plots were sown on April 30 and harvested August 28-September 1.

On June 4 when the first amputations (seminal roots) were made the average development of the seedlings was as follows: height 21 cm., main stem fifth leaf stage, four tillers, six seminal roots including the sixth, five crown roots and a distinct subcrown internode.

The records obtained have been summarized in Table II.

TABLE II.—SHOWING THE DATES UPON WHICH THE AMPUTATIONS WERE MADE, THE AVERAGE HEIGHT OF THE PLANTS AT THAT TIME AND THE FINAL HARVEST NOTES.

Amputations and checks	Date of amputation	Height at time of amputation	Notes made at harvest time Aug. 28-Sept. 1				
			Height	Total number of plants	Total number of tillers	Average number of tillers per plant	Mature heads
		cm.	cm.				per cent
Check	0	–	110	73·3	568·6	7·6	89·1
Seminal root	June 4-11	22·5	90	65·0	347·0	5·3	67·2
Subcrown internode	June 13	24·0	92·5	70·0	337·0	4·7	79·7
Crown root	June 22	38·0	97·5	62·0	350·5	5·6	91·4

In addition to the above records counts were made on the number of new seminal roots which developed on each plant in one row of seminal root amputations. They are as follows:—

Number of plants with 1 new seminal root	3
" " 2 " "	1
" " 3 " "	0
" " 4 " "	1
" " 0 " "	71

It is very probable that five seminal roots at least were amputated and consequently the development of new roots would be less likely than if only three had been cut off.

In the case of the early seminal root cuts (June 4) there were distinct signs of shock such as no increase in height, wilt symptoms and dead lower leaves. It had been very dry through the month of May, but in June there was sufficient moisture. Consequently the plants injured after the first week in June especially had very favourable moisture conditions. The seedlings, which had their subcrown internodes severed, revealed noticeable shock after the operation and lost two or three lower leaves. The crown root amputations were made on seedlings seven weeks old and which had an average of fifteen crown roots established, yet there was little evidence of shock. Timely rains fell at this period and probably had a favourable influence. Very few of the injuries proved fatal. Wireworms and cutworms killed many of the seedlings which explains the small number of plants recorded at harvest time. The plants having their crown roots amputated matured earlier than the checks, whereas the seminal root and subcrown internode injuries caused a distinct retardation in ripening.

Although yield data were not obtained the reduction in tillerage in the injured plants as compared with the check would indicate a probable decrease in yield. These reactions are considered further in the next experiment.

Exp. 6.—This test was conducted at Indian Head in 1929, its object being the same as for the previous experiment, namely to determine the influence of amputations of roots and subcrown internodes under field conditions.

The test consisted of forty rod rows placed three feet apart. One hundred kernels of Marquis 0·15 wheat grown at Indian Head were sown to a row, the seeding depth being three inches. A total of six rows was used for each type of amputation. These were divided into two plots of three rows each properly spaced and separated by check plots. A large number of extra check rows were used for a periodic study, especially of the root development, throughout the season. The plants in a certain number of these rows were operated upon at the same time as the operations were done in the regular plots. At definite

periods a number of plants from such rows were taken up for notation and comparison with uninjured checks. The measurement of height was taken from the crown to the tip of the uppermost expanded leaf until the head appeared then to the tip of the head.

The plots were sown on May 1. The seminal root amputations were done on June 10; the subcrown internodes were severed on June 14 and the crown roots amputated June 21.

The development of the plants throughout the season is recorded in Table I, from which the approximate development on the above mentioned dates may be determined. It can be seen from this table that the seedlings were in a safe condition to undergo the operation, judging by past experiments.

After the operations the plots were carefully observed throughout the season. The period of shock in the case of seminal root amputations and subcrown internode cuts lasted approximately three weeks during which these plants made little increase in height, crown root development or tillerage. Many of the individuals which lost their seminal roots did not recover. The plants subjected to crown root amputations showed only slight evidence of shock. As the season advanced there was a distinct difference between the plots in respect to maturity and rate of heading. Some records upon the development of the plants in July are shown in Table III.

TABLE III.—SHOWING THE AVERAGE NUMBER OF TILLERS AND CROWN ROOTS PER PLANT ON JULY 3 AND PERCENTAGE OF TILLERS HEADED ON JULY 17

Plot	July 3, average number of		Percentage of culms headed on July 17
	Tillers	Crown roots	
Check plants	9·0	33·0	69·0
Seminal root amputation plants	3·8	14·0	22·5
Subcrown internode amputation plants	3·1	15·4	20·0
Crown root amputation plants	7·1	21·5	72·5

The final records obtained at harvest time are summarized in Table IV:

TABLE IV.—RECORDS OBTAINED AT HARVEST TIME ON THE PLOTS OF THE FIELD EXPERIMENT CONDUCTED AT INDIAN HEAD, 1929

Amputations and check	Plants killed by shock	Total number of plants	Average height	Average number of	
				Plants per row	Tillers per plant
	per cent		cm.		
Check	0	1,318	85·5	87·8	7·2
Seminal root	43·3	306	69·8	49·8	5·9
Subcrown internode	7·2	495	74·2	82·5	5·9
Crown root	0	518	78·8	86·2	6·8

Amputations and check	Tillers ripe	Average plant yield	Reduction in total yield	Appearance of plot at harvest time
	per cent	grams	per cent	
Check	81·8	8·1	0	Fairly ripe.
Seminal root	40·6	5·3	62·7	Green.
Subcrown internode	57·6	5·7	33·8	Green.
Crown root	90·5	7·6	8·6	Uniformly ripe.

Tiller distribution as determined from harvest records is shown in fig. 3.

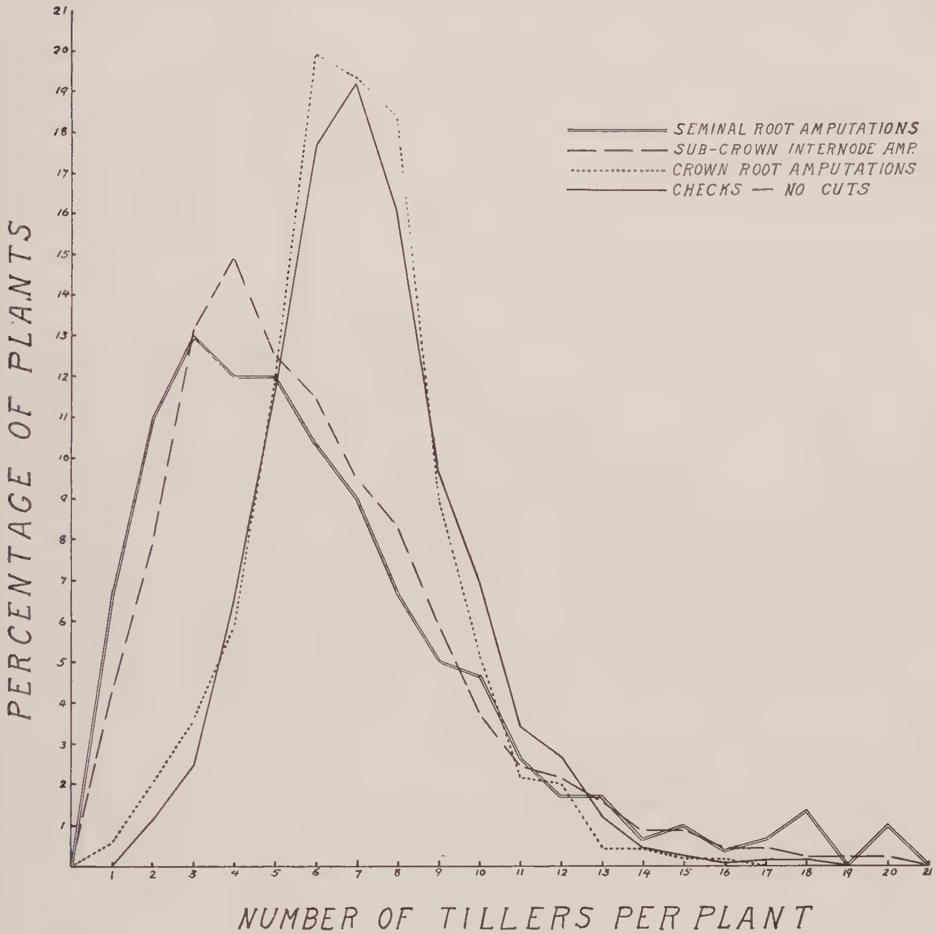

Fig. 3.—Graph showing tiller distribution for the plants in each plot as determined from harvest data in experiment 6.

The injuries received in each case during the seedling stage were evident throughout the entire development. The large percentage of seedlings which died following seminal root amputations was due largely to the size of the seedlings at that time and the very dry top soil which was unfavourable for crown root formation. Most of these seedlings lost five to six seminal roots which would occasion a considerable shock. A rather good shower of rain three days previous to the severance of the subcrown internodes probably explains the much less fatal reactions in this case. It was noted here that a large number of survivors were plants originating in the axillary bud of the coleoptile and consequently were supported by the lower root system. All final notes, however, upon subcrown internode amputations were made only on plants supported by the crown root system. There was no shock fatal to the seedlings in the crown root amputations although an average of eight established roots were cut off. In every case the injuries were reflected in the final height of the plants. The distinct difference in maturity would appear to be due to late tiller formation. In Table III, it will be seen that the plants in the check and crown root

amputation plots had about their full number of tillers on July 3. Whereas in the other two plots considerable tiller growth took place after this date. The effect of the amputations upon tiller distribution must also be considered. Seminal root and subcrown internode amputations caused an abnormal tiller distribution in comparison with crown root amputations and checks (fig. 3). When the yield for the check plot is considered as one hundred per cent, then the reduction for the seminal root and subcrown internode amputation plots is very great. The reduction in yield in the case of crown root amputations is likewise significant although much less than for the other injuries. Records of weight per measured bushel, although not shown, were made and indicated a decrease in quality comparable to the reduction in quantity.

Discussion

The significance of injuries, especially during the seedling stage, is quite well shown in the above tests. The seedlings were dependent upon the seminal roots during the early stages of growth. Once crown roots were established, however, and surface moisture was sufficient the plants could become independent of the lower root system. It has been observed, in one case at least, as mentioned above, that when the first roots are severely attacked by a fungus the crown roots are able to support the plant. Under field conditions it is frequently too dry for proper crown root development and the plant is supported by the seminal roots only. If the seminal root system under such conditions was attacked by parasites, the seedlings would have a difficult struggle. Nothing could be considered more beneficial under such conditions than a timely shower of rain to promote crown root formation. In many cases it has been observed that one form of root rot responds remarkably well after a good rain. Lateness in ripening and poor tillering have been associated with the same disease. The reactions noted in the case of seminal root amputations and subcrown internode cuts were of this nature. When crown roots were amputated, symptoms quite the opposite to the above were observed. In every case the plants matured early and uniformly. Certain other root rot diseases manifest similar characteristics. It is of interest to observe the difference in reaction depending upon the part injured.

Besides the conspicuous difference in maturity one cannot overlook the amount of injury as reflected in yields. The reduction in yield was very great in those plots in which the plants lost their seminal roots or had the subcrown internode severed during the seedling period. Furthermore on account of lateness the quality, as determined by ordinary grading methods, was appreciably affected. The injuries to crown roots caused a decrease in yield but not to the same extent as in the other cases.

The results observed were rather consistent. The injuries received in the seedling stage were reflected in an unfavourable manner at harvest time, with, in some cases, a comparable reaction between certain artificial injuries and some root rot symptoms.

Summary

1. Wheat seedlings depend largely upon the seminal root system during the early period of development.
2. After the first three weeks under favourable conditions, crown root development and tiller formation are rapid.

3. The last three weeks is a period of ripening with very little vegetative growth.
4. Seedlings one to two weeks old, by producing new seminal roots, are able to recover after the first roots are cut off. When the seedlings are older and crown roots are established the amputations cause less shock.
5. Seedlings having their subcrown internodes severed do not recover unless crown roots are established.
6. The reaction for crown root amputation is in proportion to the number of roots cut off. Seedlings may lose several large crown roots with little evidence of shock.
7. Injuries received during the seedling stage are evident throughout the growing period and at harvest time.
8. In field experiments seminal root amputations and subcrown internode cuts cause weak tillering and delayed ripening.
9. Crown root amputations under greenhouse and field conditions cause earliness in ripening.
10. The reactions expressed by plants receiving seminal roots or subcrown internode amputations are comparable with symptoms of a root rot disease which causes poor tillerage and late maturity. Crown root amputation reactions, on the other hand, are comparable with root rot diseases which produce early maturity.

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PRELIMINARY REPORT ON STUDIES OF LOOSE SMUT OF BARLEY

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Previous to the publication of Tisdale's article (1924) it was generally believed that infection of *Ustilago nuda* (Jens.) Rostr. occurred only at flowering time or shortly afterwards. It was thought that the mycelium then remained dormant in the embryo of the matured grain, over-wintered in the seed and reinfected the stands of the following year. However, the results of his investigations prove very conclusively that, at least in some varieties, a certain amount of infection may be seedling, caused by spores borne on the seed. By inoculating apparently smut-free, dehulled seeds previous to planting he has produced as high as 100 per cent infection. Moreover he showed that copper carbonate, chlorophol and similar seed treatments checked infection to some extent.

These results were surprising and contrary to the previous conception as to the nature of infection. So it is only quite recently that the question of seedling infection has assumed any proportions or importance. This new light on the life cycle of the organism demands further study. According to the Seed Growers' Association it is hard to obtain barley free from infection. It is for these reasons that I have undertaken some studies in the biology of *Ustilago nuda* which is the most important barley smut in Canada.

Collections of smutted heads were taken from the field at different dates during the summer months. Three heads hooded in glazine bags were detached from the stem daily and left in the field to August 17, to be exposed to the same environmental conditions. As the plots were visited daily the collection is more or less complete covering a comparatively wide range from July 5 to August 17.

Moreover, samples of smutted heads infected with *Ustilago nuda* were also obtained from Ottawa, Guelph, Kincaid, Alameda, Indian Head, Fredericton and Kentville. In all I had spores from twelve different sources or presumably twelve different varieties of barley. The organism was grown in pure cultures in tri-duplicate. Cultures from the same source are remaining constant while cultures from different sources are exhibiting different growth characteristics as to colour, fluffiness, aerial mycelium, spiral or whorling tendency, etc. A number of commonly grown varieties of barley have been inoculated and are being used for physiological strain determination.

Germination tests on our own local material made in October showed that the spores maturing early were not as viable as those maturing late. These tests were conducted in tap water, distilled water, 2 per cent cane sugar solution and extract of pales. The results in each case were analogous, but the per cent germination in nutrient solution was higher. Similar tests of the same material performed more recently showed an appreciable loss in vitality in both the early and late spores (Table I). The percentage germination was distinctly lowered. This raises the question, "Will the spores maturing early be capable of infection next year?"

TABLE I.—PER CENT GERMINATION IN RELATION TO TIME OF MATURITY OF SPORES

October 9, 1929

Date of maturity	Per cent germination			
	Tap water	Distilled water	2 Per cent cane sugar solution	Extract of pales
July 5	3– 5	4– 8	25–30	30–35
July 20	55–60	45–50	90–95	85–90
Aug. 4	80–85	85–90	90–95	90–95
Aug. 17	90–95	75–80	90–95	95–100

Incubation period $4\frac{1}{2}$ days.

TABLE I.—PER CENT GERMINATION IN RELATION TO TIME OF MATURITY OF SPORES—*Concluded*

December 9, 1929

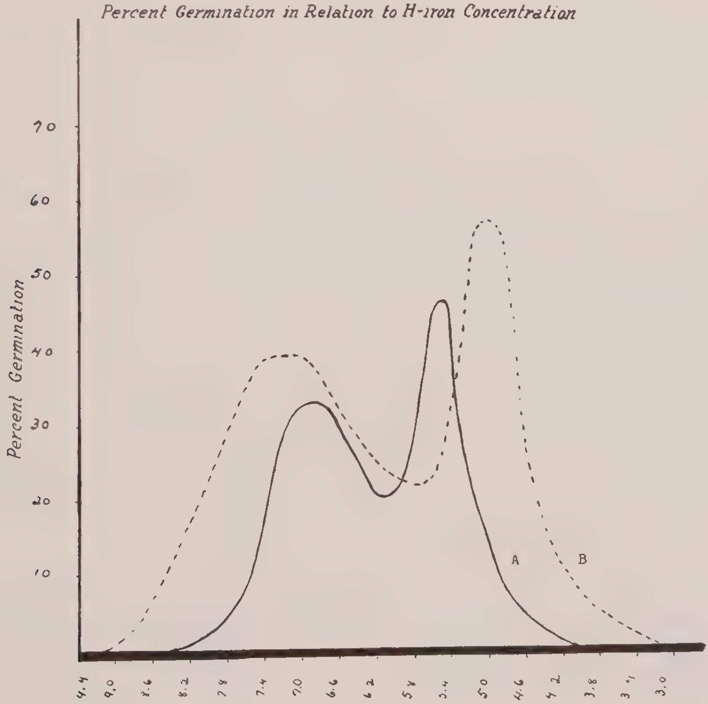
Date of maturity	Per cent germination			
	Tap water	Distilled water	2 Per cent cane sugar solution	Extract of pales
July 5	–	trace	10–12	12
July 20	10–15	35	60–75	75–80
Aug. 4	60–65	50–55	75–80	85
Aug. 17	60–65	60–65	75–80	75–80

Incubation period—4½ days.

The relation of germination to spore concentration was also investigated. Contrary to the observations of other investigators my studies demonstrate that germination is enhanced when the spores were clumped or agglutinated than when isolated or thinly scattered. This may be due to the production of carbon-dioxide which would render the solution more acid and consequently more favourable to germination.

The effect of H-ion concentration on germination has revealed a somewhat interesting phenomenon. The spores were germinated in an extract of pales and distilled water—the volumes being limited in both cases. The series had a range of ph values from 9·4 to 3 at intervals of ·4. A double optimum was evident with an apparent isoelectric point between 6·0 and 5·5. (Fig. 4.)

Percent Germination in Relation to H-iron Concentration



P.H values

A - Distilled water
B - Extract of pales
Incubation period 72 hours

FIG IV

The thermal death points have not yet been determined but it would appear from the tests made that the temperatures recommended in the hot-water treatment are sufficient to kill the spores which may be carried on the seed.

Spores were taken from eleven of the different sources to test their per cent germination within a wide range of temperatures. These were placed in sterile distilled water and incubated for 48 hours. The results obtained can best be understood by referring to the chart. With one exception there does seem to be a common optimum within a somewhat more or less definite limit of 20-22° C. With an incubation period of 4 days there did not seem to be any appreciable change in the maximum, optimum and minimum limits but there was a pronounced increase in the percentage germination. (Fig. 5.)

Germination in Relation to Temperature Showing

Maximum, Optimum and Minimum Range.

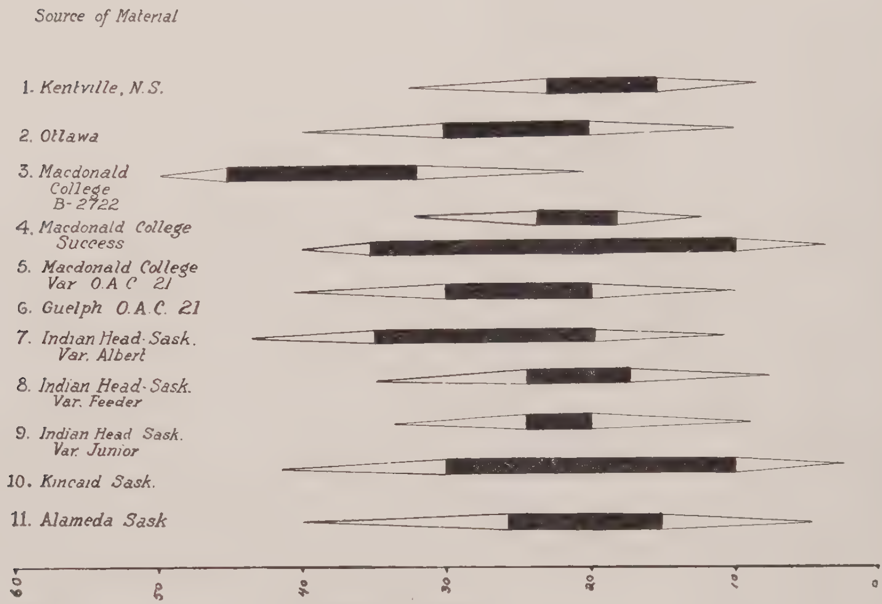


FIG. V

Temperature Range

There still remains one more interesting experiment worthy of emphasis. In bacteriology or in the study of bacterial plant pathogenes the Rideal-Walker Reaction serves a useful purpose in determining the relative values of specific germicides. I see no reason why we should not make a practice of using a simiar test in determining the comparative or relative values of our fungicides. Although I do not vouch for the absolute accuracy of these figures, I wish to emphasize the importance of the reaction and bring it to your attention for the entire sake of its possibilities (Table II).

TABLE II.—RIDEAL-WALKER REACTION

Germicide per cent concentration	Time					
	2½ m.	5 m.	10 m.	15 m.	25 m.	35 m.
Phenol—						
0·8	+	−	−	−	−	−
0·64	+	+	−	−	−	−
0·51	+	+	+	−	−	−
0·4	+	+	+	+	+	−
0·32	+	+	+	+	+	+
0·25	+	+	+	+	+	+
Copper Sulphate—						
1·5	+	−	−	−	−	−
1·2	+	+	+	−	−	−
0·96	+	+	+	+	+	−
0·76	+	+	+	+	+	−
0·61	+	+	+	+	+	+
0·49	+	+	+	+	+	+

Organism—Ustilago nuda Jens. (K. and S.)
Nutrient solution—Exptract of paḷes.
Incubation temperature.. 17° C.
Period of incubation.. 72 hours.

Phenol coefficient.. $= \dfrac{\dfrac{0{\cdot}8}{1{\cdot}5} \quad \dfrac{0{\cdot}4}{0{\cdot}76}}{2} = 0{\cdot}53$

As the preceding discussion merely constitutes a preliminary report on a portion of the work being done, it must of necessity be brief. I hope, however, that it is sufficient to give you an idea of the nature of the problem, I have undertaken as well the method of attack. A complete report will be published later.

SOME STUDIES OF SEED TREATMENT

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It has been known for many years that seeds of all plants are capable of carrying on their exterior the spores of pathogenic as well as harmless organisms. From a survey of the literature, one can obtain sufficient data to realize that the economic importance of seed treatment has not been fully realized until quite recently. A large number of important plant diseases are disseminated by the use of diseased seed, and in many of these cases, proper seed treatment would have limited considerably this danger.

There has been much research on the problem of seed treatment since the time of Prevost, who was able to discover the nature of the smut diseases and effectively control them by the use of "bluestone." Since then, a large number of new disinfectants have been discovered, but only a few of them have become popular, such as copper sulphate, formaldehyde, mercuric chloride and some of the organic mercury compounds. The latter ones, more recently introduced, have created great interest in the field of seed treatment on account of the outstandingly good results often obtained through their use. There have also been many claims that treatment with these materials has exercised a favourable influence on the yield. After an extensive review of the literature on the subject the writer has come to the conclusion that the reports seldom, if ever, show any evidence that a stimulatory effect was given to germination when healthy seed was treated. Very often, increases in germination and yield could have been attributed to the fact that the disinfectants, adhering to the seed, protected it from outside contamination with pathogenic organisms.

The purpose of these investigations was:—

(1) To study the effect of Ceresan on the germination and early growth of wheat, oats and barley, using seed grain which was reasonably free from smut infections;
(2) To test a number of seed treatments both old and new for the control of oat smuts;
(3) To study the influence of smut infection on the early growth of Liberty oats; and
(4) To study the effect of seed treatment on the stand of vegetables.

Experimental Materials and Methods

The experiments reported in this paper were carried on in the greenhouse and fields of the Department of Plant Pathology of Macdonald College, P.Q., during the winter and summer of 1928-29.

The chemicals employed as seed disinfectants were as follows:

1. Organic Mercury Compounds.—Uspulun, Semesan, Dipdust and Ceresan.

2. Iodine.—In gypsum, in animal charcoal and in infusorial earth.

3. Miscellaneous Chemicals.—Copper sulphate, copper carbonate, nickel sulphide, sulphur, Formalin dip, carbolic acid (0·5 per cent), mercuric chloride and mercurous chloride.

The dusting of seed was performed by shaking the seed and dust together in an enclosed container for about five minutes. The excess powder was then removed by screening. When cereal plants were measured, the length of a plant extending from the surface of the soil to the apex of the longest leaf was taken as such. In cases where the dry weight of the plants had to be recorded, they were removed from the soil, washed and cut across at the axis of the scutellum. These portions composed the "shoot" and "roots" mentioned later in the tables. After cutting, the portions were dried for twenty hours in an electric oven kept at 101° F.

Discussions of Results and Conclusions

The results have been summarized in tables I to V.

TABLE I.—GERMINATION AND EARLY GROWTH OF WHEAT, OATS AND BARLEY TREATED WITH CERESAN

Crop and treatment	Average germ per unit	Average height	Dry weight per unit	
			Shoots	Shoots
		cm.	gm.	gm.
Wheat (8 plots)—				
1. Untreated	88·6	15·44	2·577	0·492
Ceresan	86·8	14·53	2·735	0·508
2. Untreated	71·8	13·71	2·435	0·168
Ceresan	66·8	12·79	2·344	0·171
Oats (5 plots)—				
3. Untreated	92·2	15·88	4·191	0·411
Ceresan	98·13	15·94	4·863	0·454
Barley (5 plots)—				
4. Untreated	99·6	16·84	2·295	0·217
Ceresan	99·6	15·67	2·749	0·244

TABLE II.—CONTROL OF SMUT IN LIBERTY OATS

Treatment	Percentage of smut		
	First replication	Second replication	Average
Formalin dip	0·5	18·5	9·5
Mercury chloride	3·0	0·0	1·5
Mercury bi-chloride	0·0	0·0	0·0
Sulphur	1·0	3·0	2·0
Copper carbonate	0·0	0·5	0·25
Iodine in gypsum	3·0	32·0	17·5
Iodine in animal charcoal	4·5	6·5	5·5
Iodine in infusorial earth	4·5	12·5	8·5
Nickel sulphide	0·0	0·0	0·0
D.D.D. 42	0·0	1·0	0·5
Uspulun	0·0	0·0	0·0
Dip dust	5·0	6·5	5·75
Semesan	0·0	0·0	0·0
Ceresan	0·0	0·0	0·0
Untreated	40·5	34·0	37·25

Note.—Formalin dip has been included in these tests just as a standard treatment for comparison purposes.

TABLE III.—THE CONTROL OF OAT SMUTS BY CERESAN

Variety	Percentage of germination		Percentage of smut	
	Untreated	Ceresan	Untreated	Ceresan
Joannette 607 M.C	77·6	69·2	1·1	0·0
Joannette 407 M.C	81·5	76·1	0·0	0·0
Joannette 2007	92·3	94·6	0·0	0·0
Banner Waugh	90·7	46·9	5·9	0·0
Early Ripe 612 M.C	94·6	93·8	1·6	0·0
Black Norway	86·1	93·8	2·6	0·0
Prolific Ottawa	97·6	81·5	2·3	0·0
Garton 473	93·8	80·7	1·6	0·0
Green Russian	92·3	83·8	2·5	0·0
Liberty (1)	90·7	94·2	45·8	0·0

[1] Artificially inoculated.

TABLE IV.—THE INFLUENCE OF SMUT ON THE EARLY GROWTH OF LIBERTY OATS

Treatment	Average germ per unit	Average height	Total dry weight	
			Shoots	Shoots
		cm.	gm.	gm.
A. Check	94·8	17·58	3·320	0·169
B. Infected	94·3	15·14	2·6	0·166

NOTE.—Variety: Liberty. Date and durations of experiment: March 19 to April 9, 1929. Replications. 5 plots, 156 seeds per unit.

TABLE V.—SHOWING THE EFFECT OF DIPDUST, SEMESAN AND DELORE NICKEL SULPHIDE ON THE STAND OF VEGETABLES (AVERAGE OF FOUR REPLICATIONS)

Crop	Percentage increase (+) or decrease (−) due to treatment		
	Dipdust	Semesan	Nickel sulphide
Muskmelon	+39·0	+47·1	+ 3·6
Cucumber	+47·0	+59·4	− 4·0
Celery	−13·8	− 1·9	−10·6
Carrot	+ 1·6	− 2·4	+ 3·5
Onion	+ 3·0	+ 1·7	− 0·4
Lettuce	− 3·6	− 1·8	+ 5·6
Tomato	− 2·7	−11·2	− 0·2
Spinach	+26·0	+39·0	+ 3·4
Radish	+ 9·6	+12·2	−15·2
Cabbage	+22·0	+14·0	− 7·5
Brussels Sprouts	+11·1	+19·2	

NOTE.—For each replication 500 seeds were sown except in the case of cucumbers and muskmelons when 300 seeds were sown.

THE GERMINATION OF WHEAT, OATS AND BARLEY TREATED WITH CERESAN

As shown in table I, the Ceresan dust has been slightly toxic to the seed of Huron wheat, but not to the seeds of the varieties of oats and barley used in the experiments. The untreated plants are slightly taller than the treated in all the experiments excepting the oats, where the height is about the same. An exception occurs in the case of the shoots of wheat in experiment No. 2. It is found, on the basis of averages, that the treatment always increased the dry weight.

In general appearance, the treated plants usually were noticeably superior, the plants being stronger, the leaves broader, and the base of the stem thicker than those of the untreated plants. This is explained, from actual observations, by the fact that Ceresan on the seed preserves it and protects it from the rot-causing organisms, and therefore, the plant itself gets more food from the seed in the seedling stage and consequently is able to get a better start than the plants grown from seed not so protected.

It is concluded from these results and the survey of literature on this subject that it is not probable that seed treatment is able to exert any physiological stimulus on the germination or on the growth of plants treated with seed disinfectants, especially when healthy seed is so treated. A detailed review of literature on the subject has been made by Sampson and Davies (4) and the same conclusion has been reached. It is true also, that the retardation of growth in smutted plants as found by a number of investigators and the author himself, may be a detail leading to misunderstanding of the true factors involved when seed is treated with chemical compounds such as mercury compounds, for it is possible sometimes for treated grain to make a better growth due to chemical protection from disease. It has also been suggested that the dormancy of seeds may be overcome to some extent by the treatment. This may be taken as a form of stimulation when dormant or partly dormant seeds have been so treated.

The Control of Smut in Liberty Oats

The data given in table II shows that formalin dip, iodine in gypsum and iodine in infusorial earth gave results which varied to some extent for the two replications. Complete smut control has been obtained from treatments with Ceresan, Uspulun, nickel sulphide and mercury bi-chloride. The latter has been found to decrease the germination to a certain extent. The three iodine treatments did not give satisfactory control and germination was decreased. The D.D.D. 42, although giving good smut control, decreased germination considerably. Dipdust is the only organic mercury compound that did not prove satisfactory at least in some respects.

The Control of Oat Smut by Ceresan

Table III shows the results of some greenhouse experiments on the control of oat smut by Ceresan. All but the Liberty variety were trusted to be naturally smut infected.

We find that germination is variable, in some trials being increased through the action of seed treatment, while in others, it is decreased. The naturally infected oat varieties do not show a large percentage of smut, but when the seed is treated, even this small amount is suppressed. In the case of Liberty oats, which was artificially infected, the treatment shows no smut whatever, and the germination is slightly increased.

The Influence of Smut on the Early Growth of Liberty Oats

This experiment was carried out to compare the behaviour of healthy and smutted grain of the same variety and grown under exactly the same conditions.

As shown in table IV, there is a marked difference in the average height of infected and not infected plants. The measurements were taken after ten days growth. This difference, however, was much less marked as the plants became older. We have found that the smut fungus is directly responsible for this early dwarfing of the oat plants.

The total dry weight of the "shoots" and "roots" is likewise greater in the check, but the germination is about the same. It was observed that wilting was prevalent among the infected plants when, under the same conditions, no wilting occurred in the plants which had not been infected by the smut. It is interesting to note that the same observation was made by Koursanoff (3) on wheat, and he believed that this was directly due to higher respiration and transpiration in the infected plants. The conclusion is reached that Liberty oat is retarded in its early growth due to infection by smut organisms. Similar results were obtained by Sampson and Davies (4) in the case of wheat bunt; Koursanoff (3) for the loose smut of wheat; Buckeim and Schaneff (1) for millet smut and Talieff and Grigorovitch (6) for oat smut.

The Effect of Seed Treatment on the Stand of Vegetables

The data in table V show quite clearly that if vegetable seed is treated with a chemical disinfectant, profitable increases in stand, and sometimes, control of the damping-off disease can be secured. Bayer Dipdust and Semesan are recommended for this purpose, in the case of certain vegetables. The Deloro nickel sulphide has proved to be toxic in many cases, and also, it was of no use whatever in controlling damping-off in cucumbers, melons, spinach and lettuce.

From these figures, we find that increases in stand are obtained with musk-melons, cucumbers, spinach, radish, cabbage and brussels sprouts, when these are treated with Dipdust and Semesan. In the case of carrots, onion and lettuce, the results varied somewhat and it was impossible to draw any definite conclusions. It is to be noticed, however, that tomato and celery seed are the most likely to be injured by seed treatment. Clayton (2) also obtained quite similar results by the use of the same materials whether in the liquid or dust form for the disinfection of vegetable seed.

In many instances, the damping-off fungus, *Pythium de Baryanum* Hesse was found in the seedlings. Spinach, muskmelons and cucumbers were very susceptible to its attacks, but other vegetables, such as tomatoes, lettuce, Brussels sprouts and cabbage also suffered. Semesan and Dipdust were able to control this disease very satisfactorily in all cases except spinach, but even there, the disease was noticeably checked.

In some of the radish seedlings, some damage by a Penicillium was found. This was only in the untreated seed, but not in the treated. The fact that the two organic mercury compounds used gave very satisfactory control against Damping-off and Penicillium injury indicate at once the marked disinfective power of these chemicals. This protection arises from the fact that the soil around the seed is also disinfected, and no parasitic organisms can come into contact with the seed and remain active.

The conclusion is reached that most vegetable seed can be profitably treated with the Bayer Dipdust and Semesan, specially when the condition of germination is adverse, as in early spring.

PLATE III

A. Semesan producing good control of damping-off in muskmelons.
B. Semesan producing good control of damping-off in cucumbers.

Plate IV

A. Semesan fully controlling damping-off in cucumbers.
B. The effect of dipdust on cucumbers. Damping-off only partially controlled.

Plate V

A. Dipdust producing no difference in the stand of tomatoes.
B. Deloro nickel sulphide producing seed injury in cabbage

Summary and Conclusions

1. A number of substances have been tested for their value as seed disinfectants on various cereal and vegetable seeds.

2. Ceresan has been found very effective for the control of smut in the common and hulless oats in greenhouse and field tests. It has also proved useful by protecting the seed from soil-borne organisms, this allowing for more rapid germination and better early growth to wheat, oats and barley.

3. The same material has given indication of being slightly toxic, under the conditions of the test, to wheat and common oats, but not to barley and hulless oats.

4. Three kinds of iodine-dust treatments were tested for the control of covered smut in hulless oats, but none of them have given as satisfactory results as those obtained with other seed disinfectants.

5. Semesan, Uspulun and nickel sulphide, as dusts, gave good control of oat smut, the last mentioned being specially promising.

6. Liberty oats has been shown to be retarded in its early growth due to infection by smut organisms.

7. Increases in stand were obtained in muskmelons, cucumbers, spinach, radish, cabbage and Brussels sprouts when these were treated with Semesan and Dipdust. The treatment of these vegetable seeds with the above materials is recommended, especially when seed germination is subject to adverse conditions.

8. With the use of the same materials on carrots, onions and lettuce, the results were so variable that it was impossible to draw any definite conclusions.

9. Tomato and celery seed are readily injured by seed treatment.

10. Muskmelons, cucumbers and spinach seedlings were found to be very susceptible to Damping-off caused by *Pythium de Baryanum*, while tomato, lettuce, Brussels sprouts and cabbage were attacked to a lesser extent.

11. Semesan and Dipdust were able to control Damping-off very satisfactorily in all cases except spinach, but even there, the disease was noticeably checked.

12. It is thought that the protection afforded by a fungicide on a seed is due to the fact that the seed as well as the soil around the seed are made temporarily sterile, and few or no parasitic organisms can come into the vicinity of the seed and survive while the disinfectant is present.

13. It is concluded from the author's results and the review of literature, that it is not probable that seed treatment is able to cause any physiological stimulation to the germination or to growth of plants treated with seed disinfectants, especially when healthy seed is so protected. At times the treated seeds suffered severe injury.

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SOME EFFECTS OF GYPSUM UPON THE GROWTH AND COMMON SCAB OF THE POTATO*

(Abstract)

Gypsum has been used for many years in Europe and America for the purpose of increasing crop yields, with variable results. It has given most consistently beneficial results with legumes particularly when they have been grown on land low in sulphur. In some districts it is used as a fertilizer for these crops. It seems at times to act as a soil amendment and at other times as a fertilizer but in many cases it has produced no effect. Olson[1] has claimed that gypsum reduces common potato scab and found favourable results with applications of eight hundred to one thousand pounds per acre. Heald[2] refers to the same treatment as a control measure in his discussion on common potato scab.

This paper is a brief report of an investigation, the object of which was to study the effects of gypsum upon (1) the growth of potatoes, (2) the development of common scab of potatoes caused by *Actinomyces scabies* (Thax.) Güssow and (3) the growth of the scab organism.

Two field and two pot tests have been conducted. One field test was run at Plaster Rock, N.B., during the summer of 1927 and a second at Macdonald College, during the summer of 1928. In both cases the land was good potato land, but had been known to produce scabby potatoes in previous crops. In planting the planter was run without the covering disks in operation which placed the seed pieces uncovered in each row. This allowed for checking up on unevenness in planting. Where gypsum was used the proper amount according to the rate of application was weighed out and applied by hand in the row. This placed the gypsum in contact with the seed pieces. After this the empty planter was run down the row with the disks in operation in order to cover the potatoes. The plots were in quadruplicate, with a check on each side of a treatment. Yields were obtained at Plaster Rock but on account of the development of late blight no satisfactory yields could be obtained at Macdonald College.

One pot experiment was run in 1927 and a second in 1929. For this purpose several nine inch pots were filled with a weighed amount of suitable earth and treated with gypsum at various rates of application per acre figuring an acre as 2,000,000 pounds of soil. Ten pots were used to a single treatment and each was planted with a single tuber of approximately three ounces chosen from a uniform lot. The potatoes were planted early in the spring and after they were well up the pots were placed outside. The pots were given frequently a different arrangement in order to overcome the chance of one treatment being exposed to conditions different from the rest. The soil in each pot was inoculated shortly before planting with the scab organism from cultures.

The soils involved in all of these tests were considered to be suitable for the growing of potatoes. The reaction of all was slightly on the acid side and favourable for the development of potato scab. Uniform Green Mountain potatoes were used throughout for planting. The gypsum used was finely ground and obtained from a large deposit at Plaster Rock.

[1] Olson, Geo. A.—Agricultural Gypsum for Control of Potato Scab. Potato Magazine 5 : 7, 1922.

[2] Heald, F. D.—Manual of Plant Diseases—page 345, 1926.

* This is a shortened form of a paper published in The Quebec Society for the Protection of Plants Report for 1929. Herein is reported an additional pot test.

TABLE I.—PERCENTAGE SCAB INFECTION ON POTATOES WITH VARIOUS RATES OF GYPSUM APPLICATION

Treatment	Pot test 1927	Field test 1927	Field test 1928	Pot test 1929
Check	24·3	24·90	63·30	15·00
250 lbs. per acre	50·0	22·23	56·99	18·20
500 lbs. per acre	46·4	29·15	66·02	17·09
1,000 lbs. per acre	53·5	33·60	64·51	26·23
2,000 lbs. per acre	39·4	37·76	55·32	26·60
3,000 lbs. per acre	40·9	47·40	57·31	24·32
2,000 lbs. lime per acre	–	–	55·75	–

TABLE II.—EFFECT OF GYPSUM UPON SCAB AND GROWTH OF THE POTATO—FIELD TEST, 1927

Gypsum treatments	Per cent scab infection	Average number of tubers per hill	Yield per acre	Per cent market-able tubers by weight	Yield market-able per acre	Per cent market-able healthy tubers by weight	Yield market-able healthy per acre
			bush.		bush.		bush.
Check	24·90	4·6	177·67	71·63	127·27	53·34	94·77
250 lbs. per acre	22·23	4·5	206·53	75·06	155·02	59·02	121·89
500 lbs. per acre	29·15	4·1	182·60	75·70	138·22	50·04	91·37
1,000 lbs. per acre	33·60	3·9	170·23	78·05	132·86	53·01	90·24
2,000 lbs. per acre	37·76	3·6	170·78	80·02	136·65	47·18	80·57
3,000 lbs. per acre	47·40	3·8	172·42	81·57	140·65	37·53	64·71

In the case of the 250 and 500 pound treatments the figures for scab infection have no significance when compared to their checks.

The results obtained in these tests are summarized very briefly in tables I and II. It is to be noted that a tuber showing any visible scab whatever was listed as scabby. So many tubers that would pass in the market as scab free are here designated scabby. Table I shows that in the pot tests and the field test at Plaster Rock gypsum has increased the amount of scab development with the applications of 1,000, 2,000 and 3,000 pounds per acre. It was observed that when the number of scabby tubers was increased the amount of scab per tuber was also greater. The field test at Macdonald College gave very unsatisfactory results as the scab infection was very irregular and patchy in the field. This was believed to be due to an irregular occurrence of the scab organism in the soil. The test showed no correlation between infection and treatment and it is felt that this soil was unsuitable for such an experiment. Table II gives some data obtained in the test at Plaster Rock relative to the effect of gypsum upon the yield of the potato. Gypsum showed a tendency to reduce the number of tubers per hill and this was also found to be true in the pot experiments. The percentage of marketable tubers was increased by increasing rates of gypsum applications while the percentage of marketable healthy was reduced.

Hydrogen ion determinations made on the soils of the various treatments before and after the experiment in no case showed any change in reaction. Soil samples to which gypsum in different amounts had been added were kept in the laboratory under various conditions in order to follow any changes in reaction and none occurred in these tests. Thus any increase in scab due to gypsum could not be ascribed to a change in soil reaction brought about by the gypsum.

Various strains of the scab organism were grown in potato dextrose agar to which gypsum in amounts ranging from one half a per cent to fifty per cent

were added. This was repeated several times and in no case could any difference in growth be seen. Thus there was no indication that increased scab infection with gypsum might be due to its stimulating the organism.

Although it is realized that the investigation does not comprise sufficient tests to be conclusive yet it is felt that they demonstrate that gypsum may reduce the number of tubers per plant and may also increase the amount of common scab particularly with the heavier treatments. It would be apparently unwise to use heavy applications of gypsum upon potato soil at least until such time as the effects of such treatments have been more definitely determined. It is interesting to note that the usual rate of application of commercial fertilizer which had been used for potatoes at the Plaster Rock farm was 1,400 pounds of a 5-8-7 mixture per acre. This would supply approximately 350 pounds of calcium sulphate to the acre figuring the acid phosphate as fifty per cent calcium sulphate. From the results given above one is lead to wonder if this amount might not show a tendency to increase scab particularly if such a fertilizer were used frequently on the same soil. (J. G. Coulson, *Macdonald College, P.Q.*)

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